POWER PLANT ENGINEERING

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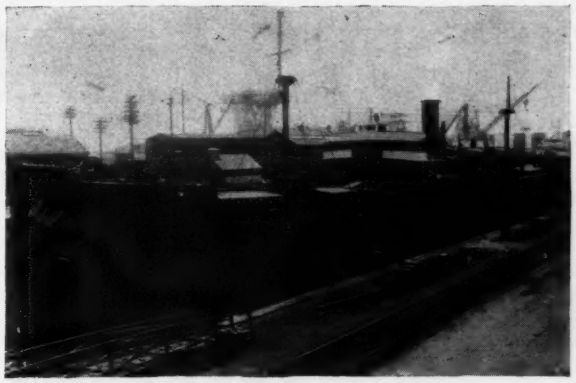


We Take a Curtain Call

DAVY JONES has expanded his organization somewhat and his most charming mermaid is going to have charge of the new PS. or Power Ship account. This will be a very valuable addition to an impressive roll which includes such names as SS., MS., USS., RMS. and HMS.

Our staff representative spent some ten days on the high seas trying to obtain a photograph of the mermaid but for the first time in a long and successful career he fell down on the assignment. The best we could do was to obtain a photograph of the first ship to bear this title, the late SS. Jacona, from the General Electric Co.

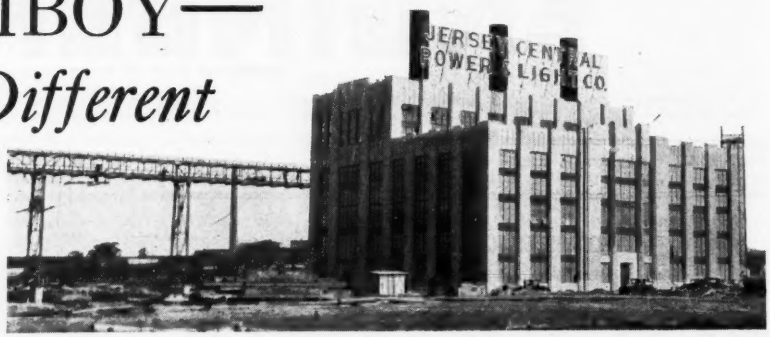
From force of habit, we almost said "late lamented" but that would not have been strictly true; there are too many brave sailor boys who tried to sail her or one of the other 100,000 of her ilk during the late effort to save Democracy.

It has been unkindly said that during the war these Shipping Board boats were launched, the machinery dumped in promiscuously, a fire of oily waste started under the stack and the ship towed out to sea. It was up to the crew to get the machinery in and operating.

Since the announcement that the Jacona was to be fitted out as a floating power plant, we have been deluged (editorially speaking) with requests for information as to the part played by our editorial "The Modern Show Boat," on page 76 of our January 1, 1930 issue.

Since the appearance of that editorial, the New England Power Co. has started construction of the 20,000-kw. power ship shown above and one of the railroads has built a portable Diesel power plant on a flat car. The editorial was inspired by the draught last year on the Pacific Coast. Our motto is "Service." If our suggestions have been of value to the industry, we feel fully repaid and feel that the applause should go to those who worked out the details.

SOUTH AMBOY— *It's Different*



JERSEY CENTRAL POWER & LIGHT CO., COMPLETING NEW PLANT ON RARITAN BAY AT SOUTH AMBOY, N. J.

JET TYPE EXTRACTION HEATERS, COAL SILOS, VERTICAL COMPOUND 1250-LB. TURBINES WITH REHEAT, FEATURES OF NEW 50,000-KW. INITIAL INSTALLATION

OF THE CENTRAL stations designed during the past year or two, the South Amboy station of the Jersey Central Power & Light Co. is by far the most interesting from many points of view. Not only does it incorporate the latest practice in the use of 1400 lb. pressure equipment but also it demonstrates a degree of thought in the working out of details that seems to be far in advance of present customs in power plant design. Combinations of equipment have been made at South Amboy that cause the observer to wonder why they were not employed before, since many of the individual elements have been widely and successfully used in other fields but have seldom been applied in the design of central stations.

SUMMARY OF INTERESTING FEATURES

Briefly, the outstanding points of interest at South Amboy are as follows:

1. Direct contact jet type extraction heaters discharging to suitable pressure stages of condensate pumps.

2. Feedwater meters taking account of temperature.

3. Coal handling system in which all coal is stored outside the building, concrete silos feeding it by gravity to the pulverizing mill feeders.

4. Provisions for maximum reliability and flexibility in firing pulverized coal by using several burners per boiler, each burner served by its individual mill, the whole under the control of a semi-manual system that premeasures coal and preheated primary and secondary air before they reach the burners.

5. Vertical compound turbine-generators operating at 1250 lb. throttle pressure, 750 deg. total temperature with five stages of extraction feedwater heating. Steam exhausted from the high-pressure turbine is reheated to

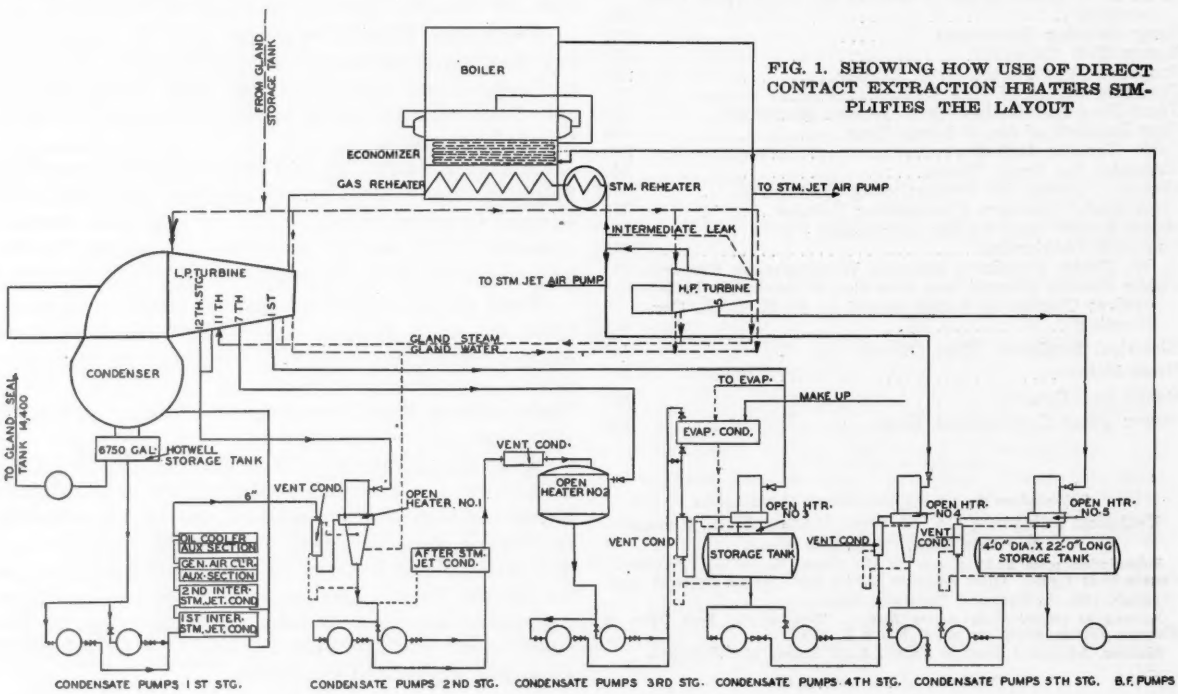


FIG. 1. SHOWING HOW USE OF DIRECT CONTACT EXTRACTION HEATERS SIMPLIFIES THE LAYOUT

750 deg. by steam and gas reheaters before it goes to the low-pressure turbine.

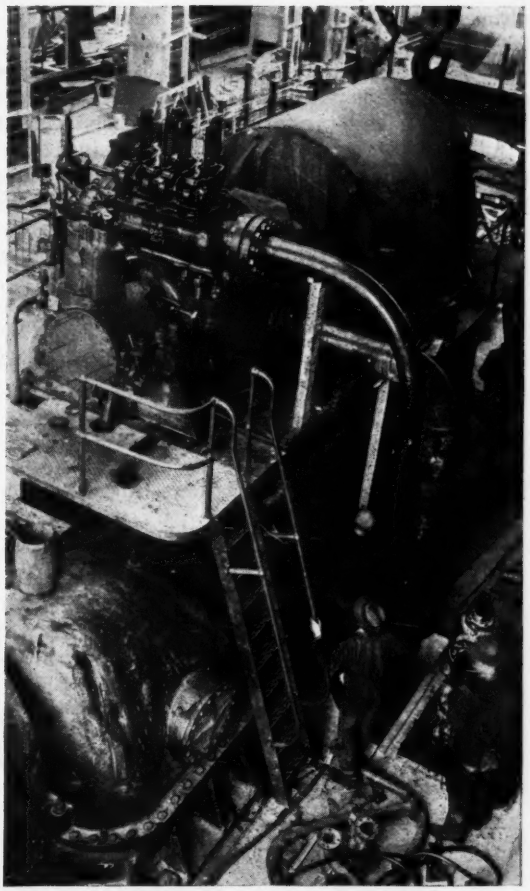
6. Boilers of the Calumet type with comparatively small boiler tube section, large water-cooled furnaces with slag tap bottoms, desuperheater to maintain constant steam temperature, gas reheater and steam reheater in series.

7. Flexibility of electrical control; use of three-winding main transformers producing three voltages for transmission.

Principal initial equipment of the South Amboy Station consists of two 25,000-kw. turbine generators, exhausting to two-pass horizontal surface condensers and three boilers each of 250,000 lb. an hour normal steam capacity at 1400 lb. drum pressure, 750 deg. total steam temperature. Each boiler has a completely water-cooled, wet-bottom slag-tap furnace of 12,900 cu. ft., fired with five turbulent pulverized coal burners taking coal from five 5000 lb. an hour air swept ball pulverizing mills.

It is evident from the foregoing brief summary that the principal equipment of the station differs in many ways from the usual arrangement. It will be seen, however, that certain equipment, such as the direct contact jet type extraction heaters and coal silos are adaptations from other fields. Certain of the metering equipment and combustion controls are of new types and a new type of pulverized coal burner will be tried on one of the boilers.

With the foregoing general impressions of the South Amboy station in mind, let us now turn to some of the details indicated.



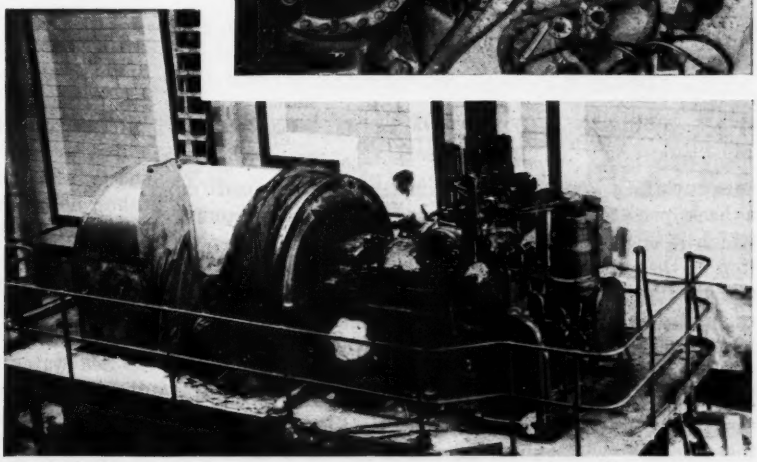


FIG. 2. (TOP). VERTICAL COMPOUND TURBO-GENERATOR, SHOWING MAIN STEAM PIPING. FIG. 3. (MIDDLE). ANOTHER VIEW OF THE HIGH-PRESSURE TURBINE ELEMENT OF ONE 25,000-KW. UNIT. FIG. 4. (BOTTOM). FRONT OF BOILER NO. 1 SHOWING THE FIVE PULVERIZED COAL BURNERS

The vertical compound turbine-generators constitute the first installation of their type to be put into operation, another installation now being made is that at Station A*. The South Amboy units are each rated at 25,000 kw.; two of this size constitute the initial installation, space being left in the turbine room for a third unit as the station expands. After No. 3, future units of 55,000-kw. capacity are planned for, to extend the

*See Power Plant Engineering, June 15, pp. 664-671.

ultimate capacity of the plant to approximately 300,000 kw.

Each high-pressure element of 5770 kw. capacity at 0.8 p.f. is mounted on the low-pressure generator frame. The high-pressure turbine element consists of a rotor of 12 stages enclosed in a machined cast-steel casing, suspended from the center-line to eliminate expansion strains. It takes steam at 1250 lb., 750 deg. F. at the throttle and exhausts to the reheater at a variable pressure and temperature depending on the load on the combined unit, this pressure ranging up to 411 lb. and the condition of the steam varies from saturated steam to slightly superheated. The generator driven by this high-pressure turbine at 3600 r.p.m., is a 13,200-v., 3-phase 60-cycle unit.

The low-pressure turbine, a 16-stage machine, takes steam at 750 deg. with a varying pressure depending on the exhaust pressure of the high-pressure element after it has passed through the reheaters from the high-pressure turbine. The low-pressure machine is designed for a back pressure of 0.5 in. mercury (29.5 in vacuum) which it is expected can be maintained during the portion of the year when the circulating water available in the Raritan Bay is sufficiently cool. The low-pressure turbine drives a generator rated at 19,230 kw. 0.8 p.f. 13,200 v., 1800 r.p.m.

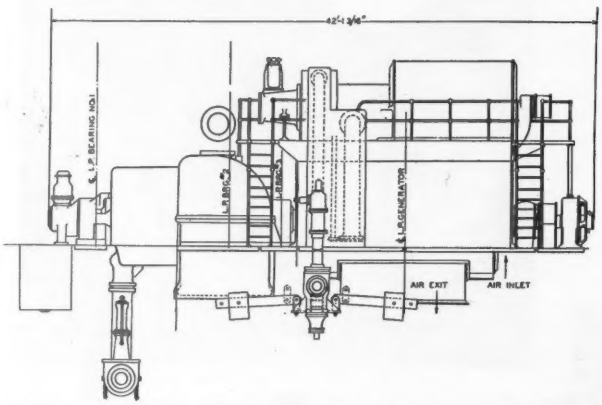


FIG. 5. GENERAL ELEVATION OF VERTICAL-COMPOUND TURBINE GENERATOR

Low-pressure casing is made of cast steel and exhaust hood is made of cast iron and expansion between the unit and condenser is taken up by spring mounting of the condenser with rubber expansion joints on the water connections.

Turbine Bearings and Lubrication

Packing for both high-pressure and low-pressure turbines is of the labyrinth and water seal type, gland sealing water being taken from the condenser hotwell storage tank, delivered by a pump to storage tanks in the upper part of the boiler room, whence it flows by gravity to the glands. As shown in Fig. 1 this gland water flows back into the feedwater circuit at the discharge of extraction heater No. 1. Gland steam from both high and low-pressure cylinders flows to the 11th stage of the low-pressure turbine. Bearings are arranged for forced lubrication and cooling by oil. Besides the main oil pump, driven through gears by the low-pressure turbine, a separate auxiliary oil pump is provided driven by a steam turbine. Incidentally, these auxiliary oil pumps and steam-jet air pumps are the only steam-driven auxiliaries in the station, all of the others being motor driven, as is the usual custom in modern stations when the extraction feedwater heating cycle is used. The steam pressure to above mentioned auxiliaries is reduced by means of fixed orifices.

The high and low-pressure units are operated as a unit and are tied solidly together on the electrical end; no provision is made for the separate operation of the two units. The generators are constructed for 13,200 v., in accordance with the usual practice of the General Electric Co.

A trip mechanism is arranged so that overspeeding of either turbine caused by electrical or other trouble the main throttle valve and the auxiliary valve on the low-pressure machine will both be tripped.

Generators are cooled by a closed air circulating system, in which fans built integral with the rotors circulate air through one set of air coolers for both generators. Cooling water for these is supplied from the first stage of the condensate pump, Fig. 1, as will be shown later.

On the low-pressure main generator shaft is mounted a 190-kw., 250-v. exciter serving both generators. As an auxiliary supply, two 190-kw. motor-generator sets can furnish power to the exciter bus.

Condensing Equipment

Low-pressure turbines exhaust into horizontal, single pass surface condensers, each with 20,500 sq. ft. of condensing surface, designed to provide 29.5-in. vacuum at full load on the turbines when provided with circulating water of proper temperature. Water boxes of these condensers are divided so that half of each condenser can be cleaned with the other half in service. Internal valves are provided in the water box partition. Tubes are of Admiralty metal rolled into both tube sheets. Provision is made for expansion by bowing the tubes, no expansion joint is used. Air is removed from these condensers by three-stage steam jet air pumps with 1st and 2d intercondensers and aftercondensers. Steam for operation of these air pumps comes from the 1250-lb. main and from the high-pressure turbine exhaust line.

Sea water from Raritan Bay forms the cooling medium for the above condensers. This water flows from the harbor to the plant through an open channel lined on the sides with interlocking sheet steel piling. After passing through the condensers, the circulating water flows back to the harbor through a similar channel and a precast concrete discharge tunnel on the other side of the power plant building, discharging into the harbor 200 ft. away from the intake channel. The intake canal and discharge canal are separated from each other by a stone breakwater. The channels are 17 ft. 5 in. wide and at low tide allows 15 ft. of water necessary for the ultimate capacity of the station. The usual trash racks are provided where the intake tunnels enter the building and ahead of each condenser are two 45,000-g.p.m. traveling screens, provision being made in screen capacity for the third unit.

Two motor-driven condenser circulating pumps, each of 21,000 g.p.m. capacity, are provided to force the water through each condenser. The intake channel runs along close beside the building with bays at each

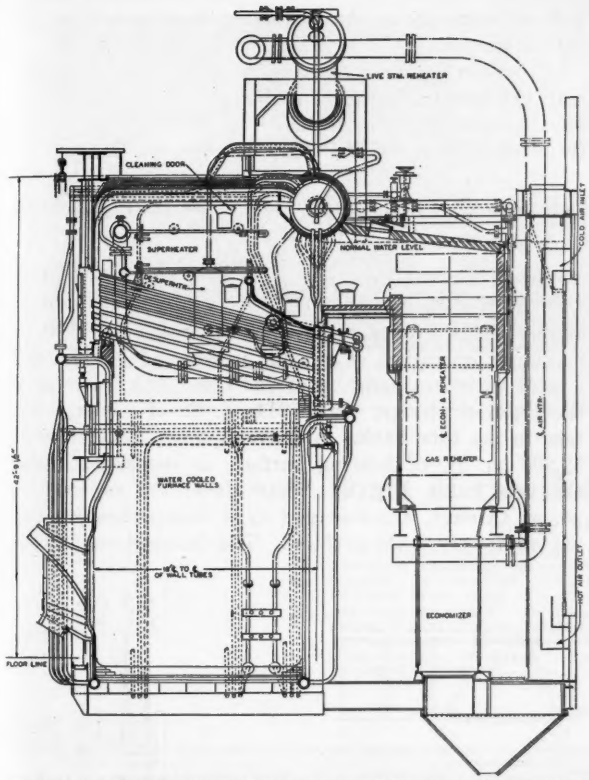


FIG. 6. STEAM REHEATER IS DIRECTLY ABOVE MAIN BOILER DRUM

end opposite the present generating units, Nos. 1 and 3, leading in to the traveling screen wells just inside the building wall, as shown in Fig. 8. A novel feature in this station is the location of the screens in separate rooms inside of the main power plant building, thereby precluding the necessity of building a separate screen house or of having the screens exposed in an unsightly manner. The suction pipes of the circulating pumps dip into this screen well; suction pipes can be led to them for the pumps of unit No. 2 when that is installed. Condenser circulating water discharges from the condensers through 48-in. pipe leading under the boiler house to the discharge channel as shown.

Direct Contact Jet Heaters Used as Extraction Heaters

Perhaps the most interesting feature of the turbine room is the group of direct contact jet type heaters used as extraction feedwater heaters. The principal objectives in using this type of heater were simplicity of equipment and operation, improvement in thermal efficiency, elimination of drip pumps and of drip cascading. Figure 1 shows the flow of steam and condensate for one turbine-generator unit. This diagram shows five stages in the condensate pumps but in reality these are in two separate centrifugal pumps; the first three stages are in one pump called the condensate pump and the two remaining stages in one pump called the booster pump. Condensate from the various heaters flows to the corresponding stage of these two pumps, as shown.

Condensate flows from the 6750-gal. hotwell storage tank to the first stage of the condensate pump which sends it through the first and second intercondensers of the condenser steam jet air pump. It goes then through the generator air coolers and oil coolers. The auxiliary sections of these coolers use condensate as cooling water; condensate being taken from the hotwell storage and circulated through the auxiliary sections under extremely light load operation and returning to the hotwell storage through the condenser, the auxiliary sections being used only under extremely light load operation and in starting when the quantity of condensate is not sufficient to furnish proper cooling.

Final Feedwater Temperature 519 Deg.

From the coolers the condensate passes through the vent condenser of heater No. 1 to the heater, which is designed to heat it to approximately the temperature corresponding to the twelfth-stage bleed point of the low-pressure turbine. From here the condensate is sent by the second stage of the condensate pump through the after-condenser of the condenser steam jet air pump to heater No. 2, a deaerating open heater designed to heat condensate to the approximate temperature corresponding to the seventh-stage bleed point of the low-pressure machine.

Now the third stage of the condensate pump picks up the condensate to send it through the evaporator condenser to heater No. 3. Thence it is pumped by the two stages of the booster pumps through heaters Nos. 4 and 5 respectively. The condensate leaves the No. 5 heater at a temperature of 519 deg. and 812 lb. when the turbine is carrying its rated overload and the boiler feed pump is handling 275,000 lb. of water per hour. Here the boiler feed pumps of 275,000 lb. per hour capacity each take the feedwater and deliver it to the economizers.

Feedwater Meters Automatically Corrected for Temperature

Because of the variation in temperature of the feedwater leaving heater No. 5, boiler feedwater meters taking account of temperature were developed to measure this feedwater by the designing engineers of the station in coöperation with the meter manufacturers. These are believed to be the first of their type and are expected to increase materially the accuracy of determining the flow of boiler feedwater.

The evaporator for makeup water is in parallel with No. 3 heater; that is, it takes evaporating steam at the temperature and pressure of the first-stage extraction

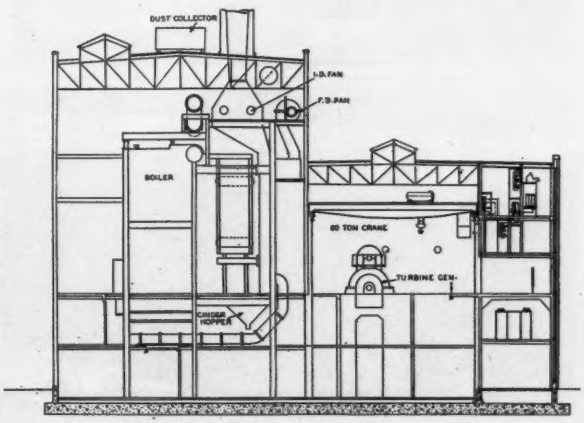


FIG. 7. GENERAL ARRANGEMENT OF SOUTH AMBOY STATION

point of the low-pressure turbine element. This evaporator is a single effect unit designed to evaporate up to 3 per cent makeup. Evaporator drains go to the evaporator condenser to heat the condensate passing through it. Makeup water supply for the evaporators is pumped from deep wells by two 250-g.p.m. vertical deepwell pumps.

Evaporated water is stored in two 10,000-gal. underground water tanks outside the station, from whence it is introduced into the system through the evaporator condenser under float control. Heaters 4 and 5 are provided with storage tanks with manometer controls governing the operation of the condensate and booster pumps. Evaporator condenser drains go to the No. 3 heater storage tank, while vent condenser drains of each jet heater go to the discharge side of its respective heater.

A system of motor-operated valves, controlled from the operating board, governs the flow of steam to the various heaters to maintain the required water temperatures. Provision is made so that, if for any reason the turbine shuts down, the extraction heaters will be cut out of service.

Provision is made to have all pumps in duplicate, both condensate, booster and boiler feed for each turbine, ample provision is made to protect the turbine from moisture entering it from the heaters.

Boilers for 1400-Lb. Operation Have High Steaming Capacity

Steam for the turbines is supplied by three boilers, each of the design shown in Fig. 6 and each built to supply 250,000 lb. of steam normally and 275,000 lb. at maximum operation, at a drum pressure of 1400-lb. and a total steam temperature of 750 deg. The boiler is of the Calumet design, with 7214 sq. ft. of heating surface in the tube bank. A convection superheater, with 12,900 sq. ft. of heating surface, is suspended above the tube bank, Fig. 6. Steam from the superheater passes through a submerged type desuperheater, Fig. 9D, on its way to the turbines. The desuperheater main-

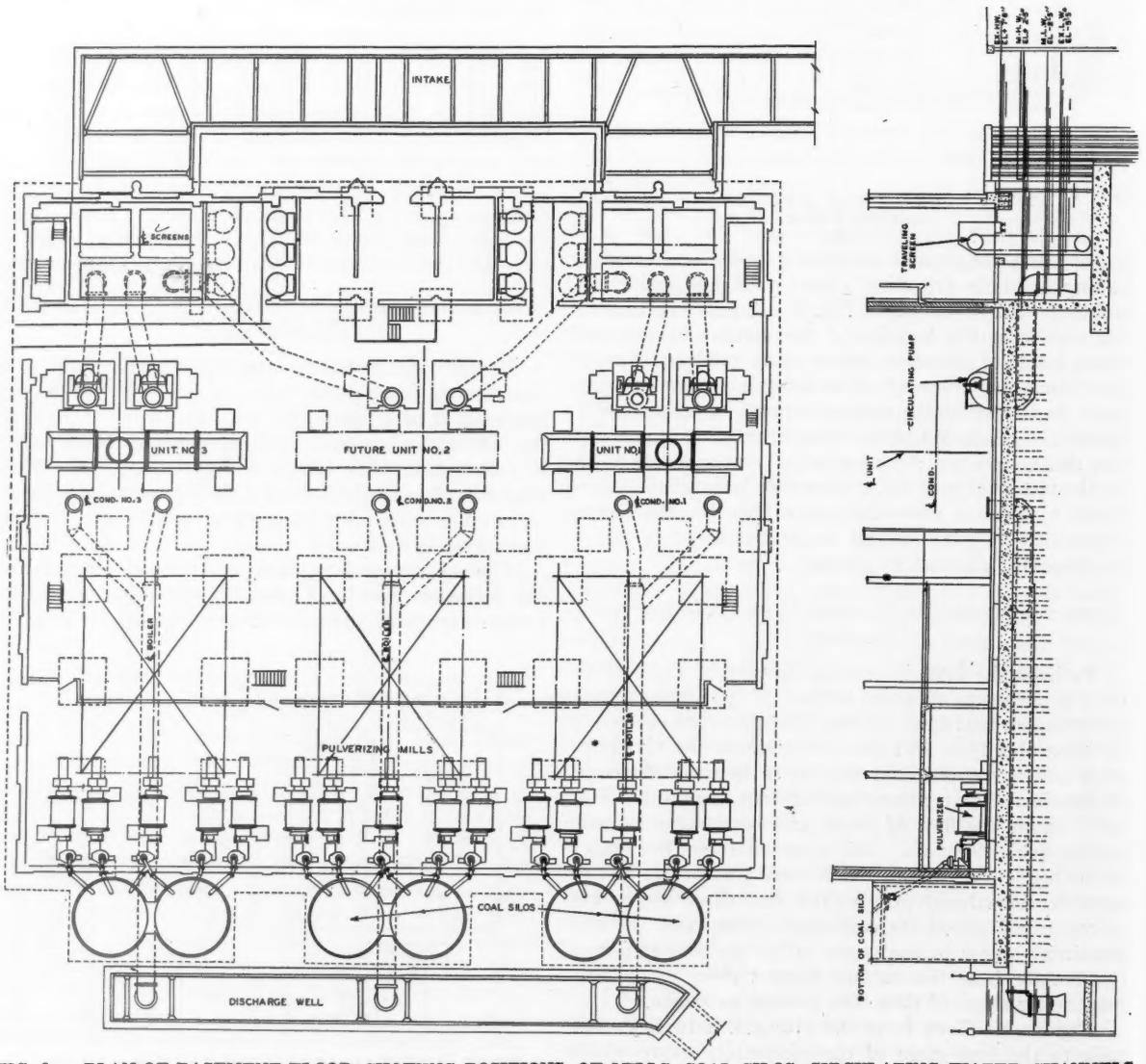
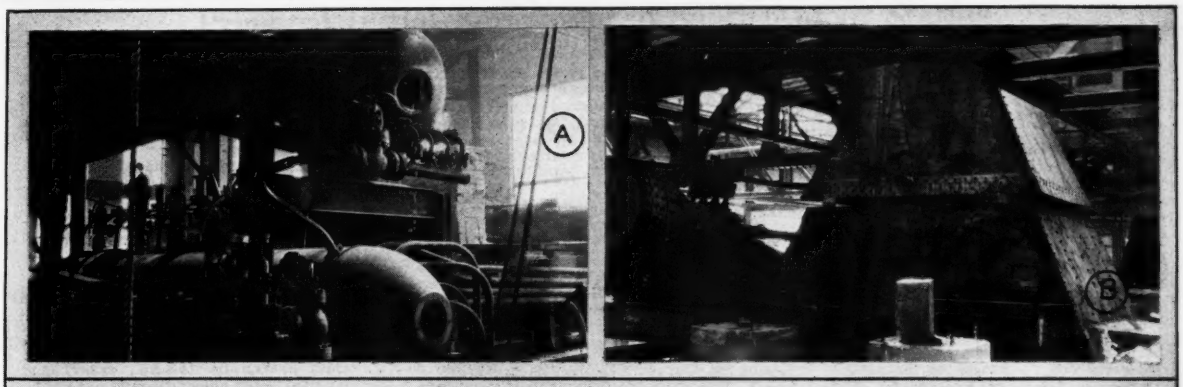


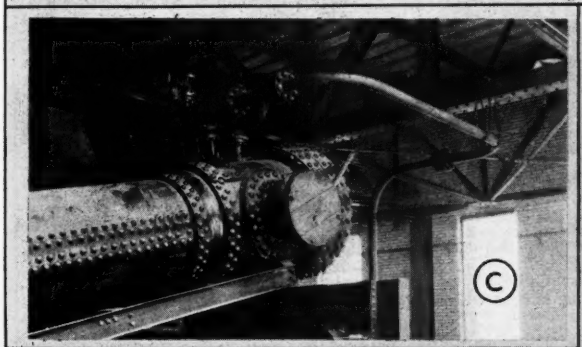
FIG. 8. PLAN OF BASEMENT FLOOR, SHOWING POSITIONS OF MILLS, COAL SILOS, CIRCULATING WATER CHANNELS AND PIPING AND PUMPS

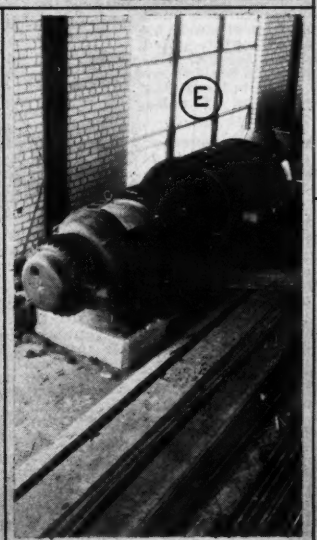


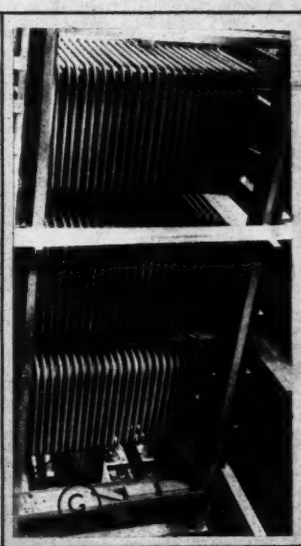
Some of the Details at South Amboy

FIGURE 9

A.—Main boiler drum, Unit No. 1, with steam reheater above it showing manifold. Boiler water column in foreground. B—Base of venturi stack, No. 1, showing location of induced draft fans. C—Closeup of steam reheater and high-pressure manifold. D—Desuperheater used to maintain constant initial steam temperature. E—Forced draft fan and driving motor. F—Access door in water-cooled furnace wall. G—Each gas reheater behind boiler proper. Contains three banks of tubes. H—Top of furnace side wall, No. 1.







Principal Initial Equipment at South Amboy Station

GENERAL DATA

Location.....South Amboy, N. J.
Service .....Central Station
Capacity, present ..... 50,000 kw.
ultimate .....300,000 kw.
Source of condenser circulating water ..... Raritan Bay
Source of makeup water.....
.....Deep wells on property
Owners .....
..Jersey Central Power & Light Co.
Engineers and constructors.....
Electric Managemt. & Engrg. Corp.
Architect...Shreve, Lamb and Harmon
Consultants for the engineers.....
.....Sargent and Lundy, Inc.

SUB CONTRACTORS

Building contractor .....
..... Deakman-Wells Co.
Boilers, superheaters, reheaters, economizers and air heaters.....
.....Babcock & Wilcox Co.
Turbines.....General Electric Co.
Switchboard .....
.....Westinghouse Elec. & Mfg. Co.
Condensers.....Foster Wheeler Corp.
Piping contractors .....
Pittsburgh Piping & Equipment Co.
Outdoor switching equipment.....
.....General Electric Co.
Furnaces—water walls .....
.....Fuller Lehigh Co.
Furnaces—refractory and arch erection.....George Allen & Sons
Flues and ducts contractor.....
.....Turl Engineering Works, Inc.
Stacks .....Prat-Daniel Corp.
Pipe covering contractor.....
.....R. H. Porter Co.
Water towers .....
....Pittsburgh-Des Moines Steel Co.
Deep wells.....Ridpath & Potter Co.

EQUIPMENT LIST

COAL AND ASH HANDLING EQUIPMENT AND STORAGE

All equipment supplied and installed by The Nicholson Co.

1 Mead-Morrison Mfg. Co. coal tower, capacity 140 t. per hr., for barge unloading.

1 Pennsylvania Crusher Co. coal breaker, 200 t. per hr. capacity.

1 Link-Belt Co. balanced skip hoist, capacity 100 t. per hr. driven by 30-hp. G.E. motor.

1 R. H. Beaumont Co. drag scraper for coal storage space; capacity of scraper 140 t. per hr.; tail block car.

1 Robins Conveying Belt Co. belt conveyor, loaded by skip hoist and discharging to silos. Belt conveyor 420 ft. long, 2 ft. wide, driven by 10-hp. G.E. motor; capacity 100 t. per hr.

6 Nicholson Co. reënforced concrete silos for coal storage, capacity 125 t. each.

1 Allen-Sherman-Hoff Co. Hydrojet sluice, with Worthington 2000 g.p.m., 525 ft. head pumps for handling slag from slag-top furnace bottoms.

Provision has been made for future installation of dust collectors.

BOILERS

3 Babcock & Wilcox Co. inclined, straight-tube, cross-drum, water-tube boilers, designed for 1400 lb. pressure, 750 deg. total steam temperature. Normal output 250,000 lb. steam an hour; maximum output, 275,000 lb. an hr. Heating surface 7214 sq. ft., tubes 3¼ in., 20 ft. long, single pass, 40 sections wide, 8 rows high.

3 Babcock & Wilcox Co. interdeck convection steel superheaters; return bend type; 12,900 sq. ft. surface to give total steam temperature of 750 deg. F.

3 Babcock & Wilcox Co. desuperheaters, submerged bent-tube type, thermostatically controlled to maintain total steam temperature of 750 deg.

3 Babcock & Wilcox Co. steel tube return-bend economizers, 4423 sq. ft. heating surface; water temperature in varies between 361 and 520 deg.; 16 rows wide; 22 rows high.

3 Babcock & Wilcox combination reheaters each consisting of a steam reheater connected in series with a gas reheater. The steam reheater contains 12,900 sq. ft. of heating surface made up of 3 groups of looped 2 in. diameter No. 10 gage tubes expanded into 12 vertical headers. The gas reheater contains 13,000 sq. ft. of heating surface made up of 2-in. tubes 24 rows wide and 42 rows high. The combination is designed to heat 226,000 lb. of steam per hour, at 400 lb. pressure, from 520 deg. F. to 750 deg. F. with 300,000 lb. gas at 1200 deg. F. entering the gas reheater.

3 Babcock & Wilcox Co. tubular air preheaters, 32,052 sq. ft. surface each, designed to pass 75,000 c.f.m. of flue gas at 250,000 lb. steam an hour output with air in, 80 deg.; out, 477 deg.; flue gas in, 635 deg.; out, 317 deg.

Tube protective coating on boilers, economizers, reheaters, etc.....
....., Johns-Manville

PULVERIZERS AND FURNACES

15 Kennedy-Van Saun Mfg. & Engrg. Corp. air swept ball pulverizers (5 per boiler). Capacity, each 5000 lb. an hour. Exhauster fan and mill driven at 1160 r.p.m. by 12 hp. variable speed a.c. motor. Coal feeders, weighing devices and measuring devices on mills worked out in conjunction with combustion control by Bailey Meter Co., Toledo Scale Co. and Kennedy-Van Saun Mfg. & Engrg. Co.

10 Fuller Lehigh Co. Calumet Burners, turbulent, 5 each for boilers 1 and 3, max. capacity 5000 lb. coal an hour.

5 Roe burners for boiler No. 2; inner tube valve control, turbulent, built by Foster Wheeler Corp.

3 Fuller Lehigh Co. complete Bailey water cooled furnaces, volume each 12,900 cu. ft., tubes protected by Bailey blocks; area water-cooled surface 2036 sq. ft., General Refractory Co.; Wynn brick wall above water-cooled wall. Wet bottom slag tap arrangement; layers of coke, sand and brick.

Furnace designed for heat release of 24,000 B.t.u. per cu. ft. per hr. at 250,000 lb. steam an hour; 26,500 B.t.u. per cu. ft. per hr. at 275,000 lb. steam an hour.

3 Boiler Control Boards built by Bailey Meter Co. Incorporating special semi-manual combustion control equipment designed by Bailey Meter Co., Toledo Scale Co. and Kennedy-Van Saun Mfg. & Engrg. Corp.; Boiler Room Improvement Co. McNeill liquid level indicator; American pressure gages; Bailey feedwater meter correcting automatically for temperature; Bailey steam flow meter; Bailey Meter Co. recording four-pen thermometer for air preheater gas and air temperatures; Bailey Meter Co. recording pyrometer for steam temperature; Republic Flow Meters Co. CO_2 recorder and indicator; Hays draft gages. Electrical controls are also provided on the boiler control panel, as follows: Ignition oil pumps, air admisison doors, boiler feed valves, I.D. fans, F.D. fans, primary air fans, pulverizers, feeders, burner dampers, emergency shut off station for all high pressure and reheat steam valves.

EXHAUSTERS, FANS AND STACKS

3 Prat-Daniel Corp. Thermix steel stacks, 1 per boiler; each 60 ft. high above roof, top diameter 10 ft. Incorporated in base of each stack are two induced draft fans each rated at 62,000 c.f.m., max. cap., at 9½ in. H_2O, driven by 150-hp., 440-v. G.E. Co. variable speed motors.

3 B. F. Sturtevant Co. forced draft fans, each 40,000 c.f.m. capacity at 8 in. H_2O; driven by 100 hp. variable speed, a.c. Fairbanks-Morse motors.

15 Kennedy-Van Saun Mfg. & Engrg. Corp. primary air fans (exhausters on mill) each 7000 c.f.m. capacity at 5½ in. H_2O. Flues and ducts furnished and installed by Turl Engrg. Works,

Damper control.....Carrick Eng. Co.

TURBO-GENERATORS AND AUXILIARIES

2 General Electric Co. vertical compound turbo-generators, each 25,000 kw. at 80 p.f. capacity. High-pressure turbine element: 12 stages, throttle steam pressure 1250 lb. gage, total steam temperature, 750 deg. Exhaust pressure 400 lb. gage. Rated at 5000 kw., 80 p.f., 3600 r.p.m. Air coolers, surface type, of 9400 sq. ft. each and oil coolers using condensate for cooling. Air coolers have auxiliary section for raw water circulation. Generator ventilating fans on generator shaft. Low pressure turbine element; 16 stages, rated at 19,000 kw., 80 p.f., 1800 r.p.m., 13,200 v. Main exciter, direct connected, 190 kw., 250 v. d.c. Two reserve exciters, G.E. motor-generator set, 190 kw. each, 250 v. d.c. Generator ventilating fans on generator shaft. Turbines bled at following points at normal full load for feedwater heating: high-pressure element; stage 5, 720 lb. abs., 640 deg. steam temp.; exhaust 358 lb. abs., 510 deg. Low-pressure element; stage 1, 158 lb. abs., 610 deg.; stage 7, 44.5 lb. abs., 380 deg.; stage 12, 8.2 lb. abs., 2 per cent moisture.

2 Foster Wheeler Corp. horizontal single-pass condensers, designed to maintain 29.5 in. vacuum at full load, 20,500 sq. ft. surface each, made up of 20,000 tubes ⅞ in dia., No. 18 B.W.G. Admiralty mixture, 20 ft. long. Tubes expanded into both tube sheets.

2 Foster Wheeler Corp. steel hotwell storage tanks below condensers, capacity each 6750 gal. Tanks rectangular with rounded sides; 45 ft. long, 8 ft. wide, 2½ ft. high.

2 Foster Wheeler Corp. triple element three-stage multi-nozzle steam jet air pumps, with 2 surface intercondensers and 1 surface after-condenser.

4 Foster Wheeler Corp. condenser circulating centrifugal pumps (2 per unit); capacity each 21,000 g.p.m. at 14 ft. head. Vertically split type bottom suction, top discharge. Driven at 200 r.p.m., by 100-hp., 440-v. Fairbanks-Morse Co. motor.

Vacuum trippers .....
.....Consolidated Engine Stop Co.

2 Pittsburgh-Des Moines Co. gland seal water storage tanks.

2 Chain Belt Co. traveling intake screens, each 45,000 g.p.m. capacity at low tide, driven by 5-hp., 1150-

Principal Initial Equipment at South Amboy Station

r.p.m., 440-v. General Electric Co. motors.

BOILER ROOM ACCESSORIES

Soot blowers for boilers, economizers, gas reheaters and air preheaters—Diamond Power Specialty Corp.

Water columns, flat type—Babcock & Wilcox Co.

Remote water level indicators—Boiler Room Improvement Co.

High-pressure steam and water piping, 2½ in. and larger, with Sarlun joints; 2 in. and smaller has ring type joints—Pittsburgh Piping and Equipment Co.

Fittings, electric cast steel—Pittsburgh Piping and Equipment Co.

Consolidated Ashcroft Hancock Co. safety and relief valves. On boiler drum No. 4, 3½ in. On superheater No. 1, 3½ in. On economizers, 2 2½-in. Yarway Co. blowoff valves. Boiler 2 sets 2½ in. (tandem); economizer 2 2½-in.; evaporators 1 1½-in. (tandem).

Boiler valves: High pressure gates, Chapman Valve Mfg. Co. High-pressure globe valves, The Edward Valve & Mfg. Co. Non-return valves, motor-operated, The Edward Valve & Mfg. Co. Check valves, Chapman Valve & Mfg. Co. Reducing valves, Foster Eng. Co. Bleeder checks, Schutte & Koerting Co. Float valves, misc., relief valves, press. regulating, etc. Motor controls for boiler valves, boiler feed and non-return, Limitorque. Others, Chapman Valve & Mfg. Co. Thermostatic controls and valves for maintaining constant total steam temperature and constant reheat steam temperature, Bailey Meter Co.

Boiler covering and insulation—Johns-Manville and Ehret Magnesia Mfg. Co.

Gratings and stairways—Schaffer Iron Works.

FEEDWATER SYSTEM

2 Dean Hill Pump Co. vertical deep well pumps for supplying makeup water; capacity, each 200 g.p.m. at 250 ft. head; 1150 r.p.m., driven by Fairbanks, Morse & Co. 25-hp., 440-v. motor.

2 Foster Wheeler Corp. evaporators for makeup water; capacity, each 10,000 lb. an hour; tube type, single effect taking steam at 180 lb. from 1st stage low-press. cyl. extraction point.

2 Foster Wheeler Corp. evaporator condensers each to heat 220,000 lb. an hour of condensate from 277 deg. to 313 deg.

8 Cochrane Corp. extraction feedwater heaters (4 per turbine) steam jet direct contact type, No. 1 taking steam from low-pressure turbine element at 12th stage at 9 lb., 2 per cent moisture; No. 3, 1st stage at 184 lb., 610 deg.; No. 4 from high pressure element at exhaust, 415 lb., 520 deg. and No. 5 from 5th stage, 842 lb., 670 deg. Each heater equipped with vent condenser and necessary controls. No. 2 heater is open heater described below. Capacities: No. 1, 320 g.p.m. of water; No. 2, 380 g.p.m.; No. 3, 445 g.p.m.; No. 4, 550 g.p.m.; No. 5, 640 g.p.m.

Schutte & Koerting Co. control valves, Bailey Meter Co. thermostats, Cochrane Co. float controls, Chapman and Limitorque on Edward motor operated valves.

2 Cochrane Corp. open direct contact feedwater heater, deaerating type, used as No. 2 extraction heater, taking steam from 12th stage low pressure turbine at about 51 lb. abs., 380 deg. To heat and deaerate 380 g.p.m.

4 Foster Wheeler Corp. centrifugal condensate pumps (2 per turbine, 1 regular and 1 reserve), 3 stage, 450 g.p.m., against 195 lb. Three pressure stages of 2 to 36 lb., 11 to 62 lb. and 50 to 195 lb. Driven by 75-hp., 1800-r.p.m., 440-v. Fairbanks Morse Co. motors.

4 Foster Wheeler Corp. centrifugal condensate booster pumps, two pressure stages of 183 to 428 lb. and 412 to 823 lb. Capacity, each 630 g.p.m. Driven at 3600 r.p.m. by 300-hp., 440-v. Westinghouse Elec. & Mfg. Co. motors.

1 Worthington Pump & Machy. Corp. centrifugal 6-stage boiler feed pump, capacity 750 g.p.m. against 1400 lb. pressure. Driven at 3600 r.p.m. by 650-hp., 440-v. G.E. Co. motor.

1 DeLaval Steam Turbine Co. centrifugal 7-stage boiler feed pump, capacity, 750 g.p.m. against 1400 lb. Driven at 3600 r.p.m. by 625-hp., 440-v. G.E. Co. motor.

MISCELLANEOUS PUMPS AND COMPRESSORS

2 Dean Hill Pump Co. gland water pumps, 30 g.p.m. at 110 ft. head, driven by 7½-hp. Fairbanks, Morse & Co. motors.

2 Pittsburgh-Des Moines Steel Co. gland seal water storage tanks, capacity, each 1000 gal.

1 Cleveland Crane & Engrg. Co. turbine room crane, 60-t. main hoist, 10-t. auxiliary hoist.

2 Ingersoll-Rand Co. air compressors, each 1200 c.f.m., capacity at 125 lb. pressure. Driven by 225-hp. General Electric Co. motors.

Schutte & Koerting Co, turbine circulating oil pumps, 10 g.p.m., driven by 1½-hp., 440-v., 1200-r.p.m. motor.

2 Hydroyl Corp. turbine oil separators.

1 Worthington Pump & Mach. Corp. ash sluicing pump, 2000 g.p.m., 525 ft. head, driven by 350-hp., 1750-r.p.m., 440-v., Fairbanks-Morse Co. motor.

1 Dean Hill Pump Co. recirculating pump, 135 g.p.m., 60 ft. head, 1750-r.p.m., 7½-hp., 440-v., a.c. Fairbanks-Morse & Co. motor.

2 Dean Hill Pump Co. hotwell overflow pumps, 100 g.p.m., 158 feet discharge, 1750-r.p.m., 440-v., 5-hp. Fairbanks-Morse & Co. motor.

BOILER AND TURBINE ROOM INSTRUMENTS

Temperature recorders ..... Bailey Meter Co.
Temperature indicators ..... Bailey Meter Co.
Thermometers..Taylor Instrument Cos.
Recording pressure gages..... Consolidated Ashcroft Hancock Co.
Indicating pressure gages..... Consolidated Ashcroft Hancock Co.
Steam flow meters....Bailey Meter Co.
Liquid level indicators..... Boiler Room Improvement Co. and Liquidometer Co., Inc.
Draft gages.....Hays Corp.
Flow indicators.....Bailey Meter Co.
Temperature controllers ..... Bailey Meter Co.

ELECTRICAL EQUIPMENT

Control switchboards ..... Westinghouse Elec. & Mfg. Co.
Storage battery, 400 amp-hr., 125 v. .....Exide Storage Battery Co.
Circuit breaker compartments (made of Zellite).....Deceleco Co.
Impregnated 3 conductor paper lead covered cable type H..... Hochstadter Co.
Power cable.....General Electric Co.
Telephone equipment ..... New Jersey Bell Telephone Co.
Turbine room signal equipment.... Westinghouse Elec. & Mfg. Co.
Load indicators ..... Westinghouse Elec. & Mfg. Co.
Steel switchyard structures..... General Electric Co.

High tension outdoor switchyard equipment. Furnished by General Electric Co., consisting of: 3 Thyrite lightning arresters, 60 cycle for 33 and 66 kv.; type E116 potential transformers with fuses; current transformers, bushing type; disconnecting switches, type RA-I; oil circuit breakers, type FHKO-139-36C-S-37A T.P.S.T.—37,000 v., 600 amp.; oil circuit breakers, type FHKO-139-42 BF—73A—T.P.S.T.—73,000 v., 600 amp.

4 main transformers, Allis-Chalmers Mfg. Co.; one bank single-phase, 3-winding, 10,000 kv-a. units; O.I.S.C., 13,800 v. Delta to 66,000/-132,000 v. Y, 33,000 v. Delta.

Indoor switching equipment: Westinghouse type FB current transformers, 2000/5 amp. and 1500/5 amp., 15,000 v., 150/5 amp. for auxiliaries. General Electric type K51 and KC-74x current transformers 2000/5 amp., 15,000 v. Westinghouse potential transformers, oil immersed, indoor type, 200 v.-amp., 13,800/115 v., type v.c. General Electric disconnect switches S.P.S.T. 600 amp., 15,000 v., type K51, also type LG-17. General Electric oil circuit breakers, type 1-FH-209, 3 P.S.T., 1600 amp., 15,000 v. (1200 amp. for auxiliaries). Westinghouse oil circuit breakers, type B-2 for station auxiliaries. Westinghouse oil circuit breakers, type B13 S.P.S.T., 400 amp., 15,000 v. Grounding reactors, Westinghouse Elec. & Mfg. Co.—15,000 v., 5 ohms, 1300 amp. for one min. Electric Power Equipment Co. selector switches, 1600 amp., 15,000 v., (400 amp. for auxiliaries). 7 Allis-Chalmers auxiliary transformers, O.I.S.C. single-phase, 60 v., 833 kv-a., 13,200/440 v., arranged in two banks.

Station auxiliary motor starting equipment and controls..... General Electric Co.

MISCELLANEOUS

2 American Radiator Co. steel heating boilers fired by Peters Central Jersey Co., Inc. oil burners, supplying steam at 15 lb. for heating station. Radiators, piping, fittings and heating system equipment supplied by American Radiator Co. Storage tanks for fuel oil—Pittsburgh-Des Moines Steel Co. Storage tanks for lubricating oil — Pittsburgh-Des Moines Steel Co. Underground storage tanks.

1 Pittsburgh-Des Moines Steel Co. spherical bottom water tower, 15,000 gal. cap., 120 ft. high.

2 Pittsburgh-Des Moines Steel Co. 10,000-gal. cap. tanks for storage of make-up water.

Steel blowoff tank, cap. 1200 gal.... Pittsburgh Piping & Equipment Co.

High pressure steam traps..... Strong, Carlisle & Hammond Co.

Unit heaters ..... Skinner Bros. Mfg. Co., Inc.

Building steel.....American Bridge Co.

Building (brickwork) ..... Deakman Wells Co.

Steel sash,.....Truscon Steel Co.

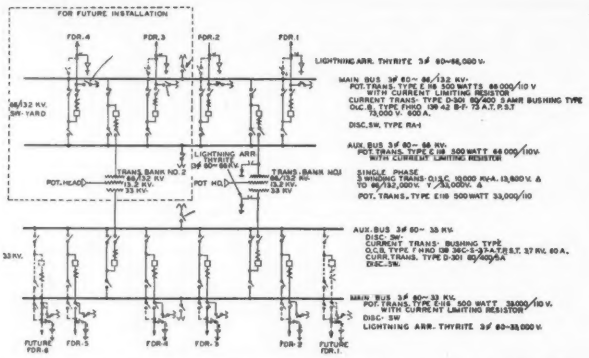

FOR FUTURE INSTALLATION
FDR.4
FDR.3
FDR.2
FDR.1
LIGHTNING ARR. THYRITE 3ϕ 60~66,000 V.
MAIN BUS 3ϕ 60~ 66/132 KV.
POT. TRANS. TYPE E 96 500 WATTS 66,000/110 V WITH CURRENT LIMITING RESISTOR
CURRENT TRANS. TYPE D-301 60/400 3 AMR BUSHING TYPE O.C.B. TYPE FHMO 138-42 B-1 73 A.T. R.S.T. 72,000 V. 600 A.
DISC. SW. TYPE RA-1
66/132 KV. SW. YARD
AUX. BUS 3ϕ 60~ 66 KV.
POT. TRANS. TYPE E 118 500 WATT 66,000/110 V. WITH CURRENT LIMITING RESISTOR
LIGHTNING ARR. THYRITE 3ϕ 60~ 66 KV.
SINGLE PHASE 3 WINDING TRANS. D13 C 10000 KVA. 13,800 V. Δ TO 66/132,000 V. Y / 41,000 V. Δ
TRANS. BANK NO. 2 66/132 KV. 13.2 KV. Δ
TRANS. BANK NO. 1 66/132 KV. 13.2 KV. Δ
POT. HEAD
POT. TRANS. TYPE E118 500 WATT 33,000/110
AUX. BUS 3ϕ 60~ 33 KV.
DISC. SW. CURRENT TRANS. BUSHING TYPE O.C.B. TYPE FHMO 138-C-2-31 A.T.R.S.T. 37 KV. 60 A. CURR. TRANS. TYPE D-301 60/400 A
DISC. SW.
33 KV.
MAIN BUS 3ϕ 60~ 33 KV.
POT. TRANS. TYPE E118 500 WATT 33,000/110 V. WITH CURRENT LIMITING RESISTOR
DISC. SW.
LIGHTNING ARR. THYRITE 3ϕ 60~33,000 V.
FUTURE FDR. 6
FDR. 5
FDR. 4
FDR. 3
FDR. 2
FUTURE FDR. 1

FIG. 10. SINGLE LINE DIAGRAM OUTDOOR SWITCHYARD

tains constant temperature of steam to the turbine, especially when the boilers are operating above normal output, when the superheat might increase beyond the desired point. The desuperheater is under thermostatic control to maintain this constant temperature automatically. Any steam made in the desuperheater is conducted to the corresponding boiler.

General arrangement of the boiler, gas and steam reheaters, economizer and air preheaters is as shown in Fig. 6. The gases of combustion pass straight through the boiler proper, which is of the single-pass type, then turning, they pass downward through the gas reheater, then through the economizer below it, then up through the air preheater to the induced draft fans. The total draft loss through this arrangement is 7 in. H_2O. at maximum rating.

The gas reheater, Fig. 9G, on each boiler, contains three banks of 2-in. tubes arranged one above the other, headed into drums as shown. Each reheater has a total effective heating surface of 13,000 sq. ft., designed to take steam at 450 lb. pressure.

Below the reheater, the economizer of 4423 sq. ft. of surface receives the combustion gases, which, in turning to go up through the air preheater, deposit any entrained soot in a hopper, from which it is discharged to the ash sluice. The economizer is of steel-tube, return-bend construction, designed for 1400 lb. pressure, to heat boiler feedwater to about 545 deg. at maximum rating before it enters the boiler.

Behind the reheater and economizer stands the tubular air preheater containing 1166 2½-in. steel tubes about 40 ft. long, giving a total heating surface of 32,052 sq. ft. Flue gas passes through these tubes and air outside them, the preheater being designed to heat 260,000 lb. per hr. of air from 70 deg. to about 467 deg. at 250,000 lb. an hour boiler output.

Fans and Stacks

Flue gas is discharged by two induced draft fans incorporated in the stack provided for each boiler. These fans each have a capacity of 62,000 c.f.m. at 9½ in. H_2O and each is driven by a 150-hp. variable speed a.c. motor. Each stack is of the steel venturi type, with the induced draft fans and gas passages designed as integral parts of the stack. It is 4 ft. 10 in. in diameter at the throat, 10 ft. in diameter at the top and 60 ft. high above the top of the boiler supporting steel on which it rests. A cylindrical casing was placed around each stack to give it the appearance of a straight steel stack but this has nothing to do with its operation. It was done solely because it was felt that the original shape of the stack did not accord with the design of the building itself.

Forced draft fans, Fig. 9E, supplying secondary preheated air to the pulverized coal burners and pulverizing mills are also located on the fan room floor above the boilers, at the same level as the induced draft fans, Fig. 9B. Two forced draft fans are provided for each boiler, each fan of the turbovane type rated at 40,000 c.f.m. capacity at 8 in. H_2O pressure and each driven by a 100-hp. variable speed motor. These fans draw air from the upper part of the boiler room, force it through the air preheater and then through a duct to the front of the boiler, Fig. 4. Further details of the air supply arrangements will be discussed in connection with the coal burning equipment.

Steam Reheaters Above Boiler Drums

Directly above each boiler drum is the steam reheater, inclined as shown in Figs. 6 and 9A. This reheater is a riveted drum 26 ft. long and 45 in. in diameter. It is designed for 1400 lb. pressure, to take steam exhausted from the high-pressure turbine at 400 lb. Reheating steam at 1400 lb., 750 deg. flows directly through a short pipe from the steam drum into the upper end of the reheater and through the tubes of the reheater, whereas the steam at low pressure being reheated is around the tube bundle. The high-pressure condensate returns directly to the boiler drum.

Steam from the high-pressure turbine to be reheated flows first through the steam reheater, then through the gas reheater and then back to the low-pressure turbine. Regulation of the flow of steam in the steam reheater by thermostatic controls governs the amount of heat added under various conditions of operation, the remainder of the heat needed to raise the turbine steam temperature to 750 deg. being added as the steam passes through the gas reheater.

All piping connections on both steam and gas reheaters are brought out to manifolds as shown. Boilers, gas reheater drums and economizers are blown down to a steel blowoff tank outside the building. Each main boiler drum is fitted with three 3½-in. safety valves

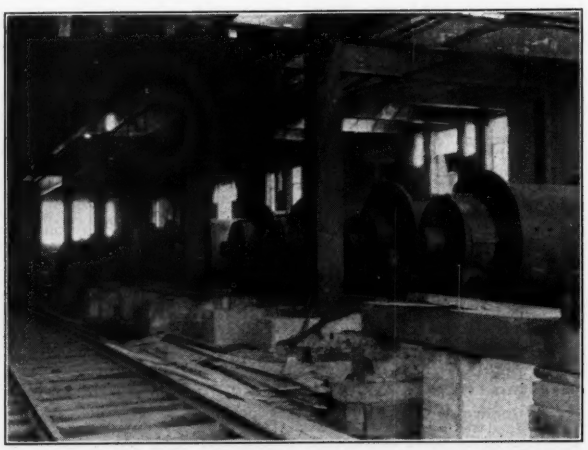


FIG. 11. FIVE PULVERIZING MILLS SERVE THE FIVE BURNERS ON EACH BOILER

and on each superheater header there is a 3½-in. safety valve.

High-pressure steam and water piping over 2½ in. in size is fitted with Sarlun joints. Boiler control valves are motor-operated.

Special care was taken in the design of the piping to relieve expansion stresses and to provide accurate and careful fitting of joints. All high-pressure joints will be tested to 2100 lb. before welding.

Water-Cooled Slag-Tap Furnaces

Furnaces of these boilers possess many interesting features. Each furnace has a volume of 12,900 cu. ft. and up to the level of the lower tube header is entirely water cooled by water tubes covered with protecting cast-iron blocks presenting a continuous heating surface to the fire. The total area of water-cooled wall per furnace is 20,036 sq. ft.

The furnace rests on a solid structural steel support at the bottom, expansion being taken up by springs at the top of the water-cooled section. Above the water-cooled wall, the boiler wall is of refractory construction. Boiler settings, together with the gas reheater, economizer and air preheater are insulated with asbestos and magnesia and the boiler drums are covered with sheet steel casings.

Access doors are provided in the water-cooled wall as shown in Fig. 9F.

The furnace is of the wet bottom slag type, in which the slag and ash resulting from combustion are kept in a molten state in the furnace bottom and drawn off at suitable intervals into a special type of sluice. In this sluice the action of water jets on the molten slag discharge breaks it up into a finely divided state so that it can be easily carried out by the sluice for disposal outside the plant.

Layers of coke, sand and firebrick are to be used in the bottom of these furnaces instead of the usual dolomite.

Furnaces are designed for heat release of 24,000 B.t.u. per cu. ft. per hr. at the normal boiler output of 250,000 lb. steam an hour.

Pulverized Coal Burning Equipment

Coal burning equipment for these boilers will probably be understood best by following the course of the coal through the system until it is burned.

Coal can be received either by rail or water. The

FIG. 12. EXHAUSTER FANS ON PULVERIZING MILLS

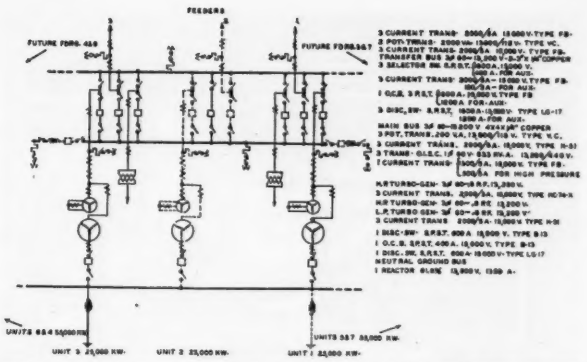


FIG. 13. SINGLE LINE DIAGRAM OF 13,200-V. SWITCHING

coal storage space, surrounded by a railroad track, provides storage space for 25,000 t. of coal, which can be distributed or reclaimed by a 100 t. per hr. drag scraper. Coal unloaded from hopper bottom cars is raised by a 140 t. per hr. balanced skip hoist to a coal breaker. This breaker is at the coal dock where a coal unloading tower also unloads directly from barges direct to the breaker.

After the coal is crushed, it can flow by gravity either to the storage space where it is distributed by the drag scraper or it can be delivered directly to a belt conveyor running to the plant. This belt conveyor discharges the coal to six 125-t. reënforced concrete silos just outside the boiler room wall.

Coal Silos and Feeding Devices

From these silos, coal feeds by gravity through spouts leading through the wall directly to the pulverizer mill feeders in the boiler room basement. From the feeders it passes over a continuous weighing device, that holds about 30 lb. of coal at a time, directly into the pulverizing mills. This arrangement is shown in Fig. 11, while Fig. 15 shows the coal silos, the steel work for the belt conveyor and, at the right, the steelwork for the breaker house, skip hoist and coal tower.

It is readily seen that in this arrangement the coal is elevated only once before it is pulverized, either by the skip hoist or by the barge unloader, to the breaker. From that point on, all coal goes either to the storage space by scraper or horizontally on the belt conveyor or downward through the silos to the pulverizing mills by gravity.

A further and important feature of the arrangement is that all coal is stored outside the plant and that inside bunkers are eliminated, thus saving considerable supporting steelwork. The only coal inside the plant at a given time, besides that in the mills, is the small amount being fed to the mills by the feeders and weighing devices. This coal could be cleared from the system in a short time if that should be necessary.

Pulverizing mills are of the air-swept ball type, each of 5000 lb. an hour capacity. Fifteen of these mills are installed, five for each boiler, each mill feeding its corresponding pulverized coal burner.

Air Supply to Pulverizing Mills

The mills are driven at 680 r.p.m. by 50-hp. motors. About 50 per cent of the preheated primary or carrying air is introduced at the entrance to the mills and the velocity of this air is comparatively low through the

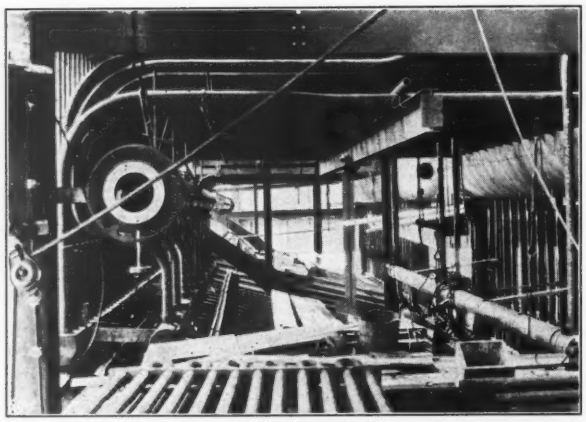


FIG. 14. SUPERHEATER HEADER, BOILER NO. 2

mill. At the mill exit the remainder of the carrying air is added and the 7000-c.f.m. exhauster driven by a 25-hp. variable speed motor at the outlet of each mill sends the pulverized coal and carrying air to the burner at a higher velocity.

Pulverizing mills are designed to maintain pulverized coal fineness of about 90 per cent through 200-mesh screen. Primary or carrying air goes to the mills from the preheated air duct about 325 deg.

Five pulverized coal burners, each served by its own pulverizing mill, supply coal to each furnace. For boilers 1 and 3 these burners are of the Calumet turbulent type. For boiler No. 2, five burners of a new type are to be installed. They are designed to produce a short, highly turbulent flame by introduction of puffs of preheated air alternately into the primary air and coal stream at the burner nozzle.

Multiple Burners and Mills Give Accurate Control

The purpose of using five burners per boiler, each fed by its own mill, is to secure accurate control to obtain uniform flame across the width of the furnace. Thus, at a given boiler operating point, each burner might be feeding a slightly different amount of coal and combustion air from others yet the flame as a whole would be uniform. The number of burners in service will be decreased in direct proportion to the load on the boiler, resulting in the operator being able to operate the maximum number of burners with the designed air velocities through the burner openings at all times.

All air for combustion goes into the furnace at the burners. Primary air taken from the preheated air duct is introduced at the mills as explained above, while the secondary air at about 465 deg., constituting 70 per cent of the total air supply, goes direct to the burners, where it is swirled into the coal and primary air stream at the burner outlet.

Combustion Control Premeasures Coal and Air

Operation of all the above combustion equipment is governed by a most interesting type of semi-manual combustion control that has been developed for the purpose. This system premeasures all coal and preheated primary and secondary air going to the mills and burners in pounds per hour, thus giving close control of the combustion process. On the boiler control board, various meters show the proper amounts of coal and air for various steam outputs of the boiler. By manual adjustment of fan speeds, mill feeder speeds, etc., the boiler operator can keep the pointers of these meters at a certain point that is known to be correct for a given boiler output. Thus he is sure that he is feeding the correct amounts of coal and air to secure the best combustion efficiency.

The boiler control board also carries the necessary steam and water flow meters, pressure gages, temperature recorders for preheated air, flue gas, reheat steam temperature and the necessary controls for motors of fans, pulverizers, boiler-feed pump and so on. As the flat-type water column is located close to the main boiler drum, Figs. 9A and 9C, a remote water level indicator is provided on the control board. Main feedwater control is remote motor operated hand control and no differential excess pressure valve is required because with the feedwater heating arrangement provided, the boiler feed pump characteristics can be designed to fit the requirements closely when operating at constant speed.

Boiler control boards are located at the center of the boiler room and the turbine room control boards are in the electrical bay, shown in Fig. 7, at the turbine level. This electrical bay contains the 13,200-v. generator

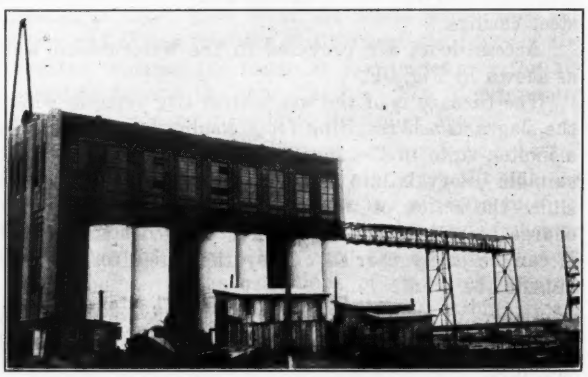


FIG. 15. EXTERIOR VIEW SHOWING COAL SILOS, BELT CONVEYOR SUPPORTS AND, AT RIGHT, STEEL FOR BREAKER AND COAL TOWER

switching equipment and houses also the auxiliary switching equipment.

Electrical Equipment

Because of the necessity of connecting the station with transmission lines of various voltages—33 kv., 66 kv., and 132 kv.—the main transformers are wound to produce those three voltages and switching is carried out on both low-tension and high-tension sides of the transformers. Figure 13 shows the main generator connections and Fig. 10 shows a single line diagram of the high-tension switchyard.

Generators feed power at 13,200-v. to a double bus system, consisting of main and transfer buses, the other side of the generator connecting to a neutral ground bus. Suitable 13,200-v. oil circuit breakers, disconnecting switches and selector switches permit various connections of the units to meet the operating conditions.

Power for the station auxiliaries and lighting circuits is taken off the main bus through a bank of three 833-kv-a. O.I.S.C. transformers that step the voltage from 13,200 down to 440 v. As noted above, all auxil-

iaries except auxiliary oil pumps and steam jet air pumps are driven by 440-v. alternating-current motors. Some of these, such as fan and exhauster drives, pulverizing mill feeder drives, etc., are variable speed units.

Auxiliary Power

Auxiliary power from the 13,200/440-v. transformers is fed to an auxiliary bus from which the circuits lead through oil circuit breakers to the motors. Double 440-v. feeders are used so that where duplicate units are installed,—the two forced draft fans for each boiler, for example—one motor will be served by one feeder and the other motor from the other feeder. Other auxiliaries such as pulverizers, pumps, air compressors and traveling screen motors, obtain their power from 440-v. sub-buses, which in turn are usually fed by two separate feeders from the auxiliary buses. The turbine room crane obtains power direct from the auxiliary bus.

Power for the coal handling equipment is fed by duplicate circuits to a control board in the coal handling tower, where the control for hoists, conveyors, drag scraper and other equipment is centralized. Lighting transformers and two motor-generator sets connect by a separate feeder and circuit breaker to the middle of the auxiliary bus, through oil circuit breaker and disconnect switches, so that they can be operated from either half of the bus in case of trouble. Each turbine is provided with a special motor for rotating the turbine slowly when the turbine is not in service so that the turbine shaft will not take any temperature set.

From the 13,200-v. generator buses, the power cables run in underground conduit to the main transformers in the high-tension switchyard. The present installation consists of a bank of three single-phase, three-winding transformers, (with one spare) of the oil-insulated, self-cooled type, each rated at 10,000 kv-a., 13,800 v. delta to 66,000/132,000 v. Y. to 33,000 v. delta, 3 phase, 60 cycle.

The 33,000-v. transformer winding connects through 37,000-v. oil circuit breakers to either a 33,000-v. main or auxiliary bus supplying the 33,000-v. transmission lines. The 66,000/132,000-v. winding connects through 73,000-v. oil circuit breakers to either a main 66,000/-132,000-v. bus or to an auxiliary 66,000-v. bus. From these buses lead the 66,000 and 132,000-v. transmission lines. All lines are equipped with Thyrite lightning arresters. Disconnecting switches are gang-operated.

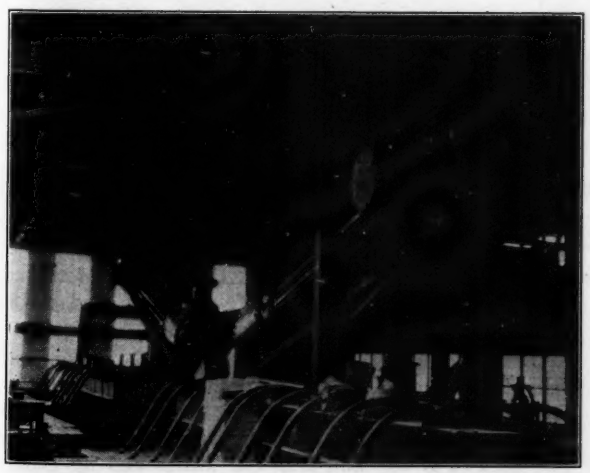


FIG. 16. LIVE STEAM REHEATERS, NOS. 1 AND 2

The station control room from which the above equipment is operated is on the turbine level of the electrical bay in the station. Besides the main control board this room contains the turbine control boards. Adjacent to the control room on one side is the load dispatcher's office, while on the other side are the chief engineer's office and the laboratory.

For heating the South Amboy station a separate low-pressure heating system is installed. Radiators are located beneath the windows in boiler rooms and unit heaters will be employed at other locations as needed. Two oil-fired heating boilers, located in the base of one of the coal silos, supply steam for the heating system. It was thought best to use separate heating boilers in this project in the interest of simplicity, to avoid interference with the bleeder system of the turbine, to insure proper building heat regardless of the operation of the plant and as a matter of keeping correct records as to operating costs.

In the boiler room and turbine room basements are located the usual air compressors, service pumps and other auxiliaries. The air compressors at South Amboy are of such size and capacity as to permit the use of compressed air for blowing soot.

Station Is Example of Good Architecture

Both interior and exterior of the South Amboy station present a most pleasing appearance. As shown in the headpiece, the building design is simple; it is dependent on two principal masses, with good fenestration. The vertical lines of the pilasters, the conservative decoration at the top of each pilaster and the continuous horizontal lines of the stone trim at the top all contribute their parts to the total satisfactory effect.

The station is of light buff face brick and steel construction. As is evident, the wall space between pilasters is practically all window, providing splendid lighting and ventilation. This is especially noticeable in the boiler room, where the absence of overhead bunkers permits full advantage to be taken of the windows and the monitor over the firing aisle.

The interior of the boiler room is left in the original light colored brick of the building walls. In the turbine room, however, an unusually pleasing appearance is obtained by use of glazed tiled walls with panels outlined by rows of dark brown tile. The turbine room floor is of brown tile.

It is evident from the foregoing description that South Amboy plant differs in many of its details from other power plants. Simplicity of operation and high economy with low first cost were the fundamental requirements that determined many of these details.

A point of particular interest in the design of the South Amboy station was the close coöperation and interchange of ideas existing between the architects, manufacturers and engineers in the design of this station. The result is an outstanding example of what can be done by utilizing the ability and initiative of those involved.

The South Amboy station was designed and constructed by the Electric Management and Engineering Corp. of New York City for the Jersey Central Power and Light Co., an operating subsidiary of the National Electric Power Co.

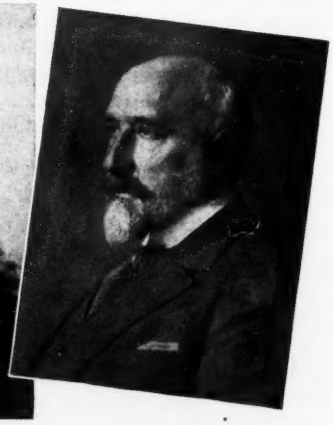


FIG. 1. CHAIRMAN O. C. MERRILL, AMERICAN COMMITTEE FIG. 2. HEADQUARTERS OF CONFERENCE IN HOUSE OF THE VEREIN DEUTSCHER INGENIEURE FIG. 3. GENERAL DIRECTOR DR. ING. C. KOETTGEN

Second World Power Conference at Berlin

TECHNICAL AND GEOGRAPHIC SCOPE OF PAPERS, THOUGHTFUL PROVISIONS FOR VISITORS, WORLD RENOWNED PERSONNEL OF SPONSORS WERE IMPRESSIVE FEATURES OF CONFERENCE AS OBSERVED BY A. L. RICE, EDITOR OF POWER PLANT ENGINEERING

FORMED IN the effort to secure better economy of power and greater utilization to increase the productiveness of workers, the World Power Conference met in Berlin for its second plenary or full world-wide session, June 13 to 25. Since the first meeting in 1924, sectional meetings devoted to special topics have been held in 1926 at Basle, Switzerland, on Water Power and Navigation; at London, 1928, on Separation and Use of Byproducts of Fuel; in 1929 at Barcelona, Spain, on Water Power Development; at Tokio, Japan, 1929, on Power Development and Problems in the Far East.

Here, at the second plenary session, the entire range of power development, use, economies and economics was considered. The organization has been perfected and made permanent so that at Berlin 48 countries were represented by official delegates.

Scope of the discussions covered Sources of Power, including fuels, water power, wind power and solar energy; Power Production, Transmission and Storage, covering steam, combustion-engine and water power generation, electrical and mechanical transmission and storage; Utilization of Power for manufacturing, agriculture, building, mining, transportation and the household; General Subjects such as legislation and regulation, economics of distribution and load, coöperation and standardization, technical education.

That only a few high points can be covered will be evident when it is considered that over 400 papers were presented and discussed at 52 meetings during nine days. Many of the papers will be abstracted in this and future issues of Power Plant Engineering.

As so many nationalities and languages were represented a thoughtful provision was made by the German Committee so that all discussions and abstracts were translated into German, French and English as given and a triple telephone system gave each visitor his choice of the language which he best understood.

At the head of the Conference organization were the Rt. Hon. the Earl of Derby, Honorary President and his Excellency Dr. Ing. Oskar Von Miller, Honorary President Elect and President Von Hinderburg as Sponsor. Actively heading the Conference was General Director Dr. Ing. C. Koettgen, Chairman and D. N. Dunlop, chairman of the International Executive Council. For the permanently organized American Committee, Robert P. Lamont was honorary chairman, O. C. Merrill, chairman, Henry J. Pierce, vice-chairman and H. M. Addinsell, treasurer. To the excellent work of these men and their co-workers was due the success of the Conference and the ideal arrangements for the comfort and benefit of delegates and guests on the way to and after the Berlin meeting.

Mention should also be made of the unremitting care given by Dr. Matschoss, president of the executive committee, in looking after the arrangements and details so important to smooth operation of the many sessions and excursion trips.

As suggested by Mr. Dunlop, it would be no tribute to the intellectual capacity of this age if developments of such importance as generation and use of power were left to chance. Scientific guidance is needed with careful investigation of difficulties and problems, exchange of experiences and definition of the function which power should play in the development of industry, taking account of the diversity of conditions to be met in different countries.

Greater service to humanity, the keynote of the activities of the engineering profession, was and is the object of the World Power Conference.

Arriving in Berlin after a comfortable voyage and delightful renewal and formation of friendships on shipboard, the first formal event was a reception of members of the Conference by Honorary Presidents The Earl of Derby and Dr. Von Miller and by Chair-

man Dr. Ing. Koettgen in the Reichstags Building. Some 300 delegates were present from America and corresponding numbers from the other participating countries, a truly international meeting.

By no means least of the opportunities afforded delegates was that so freely offered for study of power plant practice and equipment extended by the Government and by manufacturers in Berlin and environs during the Conference and in all parts of Germany on the extension tours after the Conference. Such developments as the 3000-lb. Benson boiler, high-speed, two-pole alternating-current generators, lignite-burning plants and high superheat operation could be studied at first hand.

It was, of course, necessary to hold simultaneous meetings on various subjects but so satisfactorily was the program laid out that, no matter what one's special interests, at all times meetings or inspection trips concerned with his specialty were awaiting him.

Progress in Various Countries

Monday's opening session was held in the State Opera House, followed by technical meetings dealing with Uses of Electricity in the Household and in Agriculture, Production and Preparation of Solid Fuels and Problems Relating to Water Power Rights.

In the first meeting, comparison of practice was brought out of methods and progress in Germany, France, Great Britain, Italy, Japan, Canada, Norway, Austria, Sweden and the United States.

Of like geographic range was the discussion on solid fuels, covering coal specifications, low temperature carbonization, coal cleaning, coke production and progress in fuel efficiency.

Water rights problems included legislation on disposal of power, codes for hydraulic tests, water power regulation and resumé of the results of the Basle and Barcelona meetings. Papers came from Argentine, France, Italy, Austria, Dutch East Indies and Checkoslovakia.

It was brought out by C. A. Cameron Brown of England that experiments on the use of electricity to stimulate crop growth had increased the yield 22 per cent at a cost of $10 an acre. In dairy farming, a consumption of 42 kw-hr. was found per cow for pumping and milking for a herd of 25, and 28 kw-hr. for a herd of 64. In the latter case, the saving over hand labor was $1050 a year.

Practice in the use of electricity for home and farm was summarized for Germany, France, Italy, Japan, Great Britain, Canada, Austria, Norway, Sweden and the United States. F. A. Gaby outlined at length the increase in rural use of electricity due to low rates,

FIG. A. WORLD POWER CONFERENCE PARTY ON BRIDGE DECK OF S. S. RESOLUTE

Top Row.—A. L. Rice, R. P. Pfaehler, L. F. Harza, H. A. Smith, C. B. LePage, R. B. Barnes, E. N. Trump, L. W. W. Morrow, L. C. Marburg, P. W. Thompson, Capt. F. Kruse, C. B. Richardson, W. Richardson, Jas. A. Powell, W. M. Carpenter, Dr. W. Parey, W. H. Jourdin, A. W. Moulder, A. M. Greene, Jr., P. S. Donnell, E. E. Woodward, D. B. Rushmore.

Second Row.—C. H. Sharp, L. K. Malvern, R. Sibley, I. E. Moultrop, John Hunter, F. Hodgkinson, F. S. Clark, Miss Lucille Clark, C. W. E. Clarke, G. W. Hamilton.

Third Row.—Dr. G. Egloff, W. Smith, Mrs. Clayton Sharp, Mrs. R. P. Pfaehler, Miss Rosemary Barnes, Mrs. C. W. E. Clarke, Mrs. C. B. LePage, Mrs. C. S. Glenn, Mrs. J. A. Powell, Miss M. E. Freeman, Miss Rebecca Smith, Mrs. Walton Smith, Mrs A. L. Rice, Mrs. G. W. Hamilton, Miss Carolyn Smith, Miss M. H. Powell.

Fourth Row.—Miss Kate Gleason, Mrs. J. R. Freeman, Mrs. L. K. Malvern, Mrs. W. H. Jourdin, Mrs. J. S. Kuhn, Mrs. John Hunter, Mrs. H. A. Smith, Mrs. A. M. Greene, Jr.

Fifth Row.—E. C. Hutchinson, Miss Marjorie Trump, Miss M. E. Sharp, Miss B. E. Powell, Miss Etta Burhorn, Edwin Burhorn.

which have been progressively reduced. He gave as the cost of single-phase line of aluminum stranded with steel reënforcing $1020 a mile and for three-phase, $1257 a mile.

For a small farm to cover lighting, irons, water and a 3-hp. motor, the installed capacity was 5224 watts, yearly use 2196 kw-hr. and cost $78.71, the service

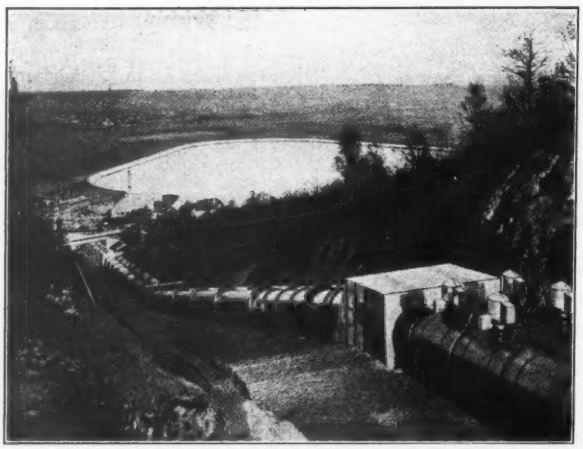


FIG. 4. PUMP STORAGE PLANT AT NIEDERWARTHA. PIPE LINE 2600 FT. LONG TAPERED 11.5 FT. TO 8 FT. HEAD 470 FT. TWO PUMPS, 2650 GAL. PER SEC. EACH 27,000 HP. RAISES WATER FROM LOWER RESERVOIR ON OFF-PEAK. DURING PEAK 30,000-KW. TURBINE DRIVES MOTOR AS GENERATOR

charge being $3.20 a month and current rates 3 cents for the first 42 kw-hr. a month and 2 cents for the balance.

For a larger farm having a water system, range and incubators in addition, the installed capacity was 13,873 w., yearly use 7147 kw-hr. and cost $167.73, rates being the same.

Investment for 30,000 customers on rural lines is $7,054,654. Yearly revenue was given as $1,342,624. Operating cost $815,281. Fixed charges as $443,837. Surplus, $83,515.

Low temperature distillation has been extensively tried out and in any effort in this direction it is important to determine the object to be attained. At present prices of by-product, the value of such distillation to obtain those products seems in doubt. If making gas is the object, the expense must be borne by the gas; if coke is desired, it must pay the cost. Externally fired retorts, for which fixed charges at 20 per cent are about $1 a ton and operating cost $1 a ton give lump coke and a rich gas; while internally heated retorts may give lump coke but produce a low grade gas. In either case, distillation at less than 1800 deg.

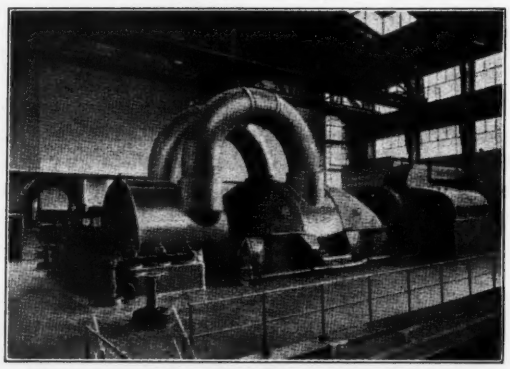


FIG. 5. 100,000-KW. GENERATOR AT GOLPA. THE LARGEST IN EUROPE

gives ammoniacal liquor too weak to be valuable.

Coal and coke specifications, coke manufacture and methods of coal mining were other subjects discussed in Section 12.

High Capacity Steam Boiler Economies*

FURNACES, BOILER REQUIREMENTS, ACCESSORY EQUIPMENT AND OPERATION. BY E. R. FISH**

WHILE SIX POUNDS evaporation per square foot of boiler heating surface was, not so long ago, considered uneconomical if not unsafe, 16 to 18 lb. are now frequent and 24 lb. have been recorded. As a basis, it will be assumed that average evaporation of 15 lb., or a heat transfer of 15,000 B.t.u. per square foot an hour constitutes high capacity, which means that for surface exposed to radiant heat as well as contact with hot gases transfer rate may run up to 125,000 B.t.u. Carbon dioxide should run 14.5 to 15.5 per cent and furnace temperature 2200 deg. F.

High capacity depends on accompanying apparatus such as superheaters, reheaters, economizers, air heaters and furnaces, hence an installation must be considered from the standpoint of the complete heat balance with each part doing its assigned work.

Long stokers and high draft have increased combustion rates to 70 lb. per sq. ft., releasing approximately 1,000,000 B.t.u. which should evaporate 800 lb. of water. This can be done only with coals having no considerable per cent of volatiles, so that much fuel is burned on the grate. Furnace volume is needed to give maximum heat release of 60,000 B.t.u. per cubic foot per hour. Rear walls and a band above the stoker sides must be protected from high temperature, usually by water-cooling.

For pulverized coal burning, 35,000 B.t.u. per cubic foot of furnace may be taken as maximum heat release with turbulent firing so that combustion is completed before gases reach the boiler heating surfaces. Firing from the top requires furnace height of 15 ft. and flame travel of 30—35 ft. Horizontal firing near the bottom calls for 15 ft. across the furnace and height of 20 ft., firing from opposite sides being an aid to turbulence. Tangential turbulent firing from the corners

*From a paper before the World Power Conference at Berlin.
**Combustion Engineering Corporation.

is directed to give a circle some 5 ft. diameter in the middle and requires 20 ft. height.

Furnace Wall Conditions

Plain refractory walls permit heat release rates up to 14,000 B.t.u. per cu. ft. per hr., air-cooled walls up to 18,000 B.t.u. and water-cooled walls up to 35,000 B.t.u.

To save walls from slagging and erosion, at high temperatures water-cooling is necessary and these walls now form an important part of the heating surface. Radiant heat is rapidly absorbed so that steam forms a large part of the content of the wall tubes, especially near the top. This requires connections to give good circulation, the area for water supply at 400 lb. pressure being 15 to 40 per cent that of the tubes, preferably by one branch to every 3 to 7 tubes. Uptake risers should have area 20 to 25 per cent greater than supply connections and also be taken off in branches.

Ash Disposal

Unconsumed fuel loss increases with high combustion but should be not over 5 per cent for stokers and 2 per cent for powdered coal. Disposal of incombustibles is now the greatest difficulty. Slag screens, i.e. wide spaces of 10 to 12 in. between lower rows of boiler tubes help to cool molten ash before it reaches closely spaced tubes and prevent bridging between tubes so that accumulated ash will fall off of its own weight or can be readily blown off by steam jets.

Twenty-five to 50 per cent of the ash is deposited along the path of gas travel in dry ash or slag top furnace bottoms or in pockets and is removed at intervals. The other 75 to 50 per cent is carried through the boiler with the gases and several methods, some showing fairly satisfactory results, are being developed to separate this ash from the chimney gases.

Steam Space Needed

With introduction of water walls, superheaters, air heaters and economizers, boiler heating surface may be as low as 12 per cent of the total heat absorbing surface although 30—40 per cent is usual. To get the desired superheat, no moisture should go to the superheater and internal baffles or separators are needed in steam drums to free steam of all wetness.

Plenty of steam space is essential. For cross-drum boilers, one cubic foot per 1000 lb. steam capacity an hour is needed at 400 lb. pressure, higher pressures requiring more and vice-versa. Multiple-drum boilers can do with one cubic foot per 400 lb. steaming capacity up to 500 lb. pressure but for higher pressures they need nearly as much steam space as the cross-drum type. Circulators between drums must be provided sufficient to ensure that the intended steam space will be maintained. A velocity of 2000 ft. per min. through circulators has been satisfactory. If loads are exceedingly high, dry drums aid in maintaining steam quality.

Present day superheating is a problem to be solved by locating convection superheaters near the furnace to contact with gases at 1800 to 2000 deg. F. and supplementing them with radiant superheating surface in the furnace walls.

Flue gas exit temperature may be as high as 1200 deg. F. For over 600 deg., use of an economizer is indicated and possibly air preheating. With high gas temperatures, economizers may make steam at times, which is not objectionable if provision is made for removing it by having discharge at the top and several connections from economizer to boiler. For low gas temperatures, additional boiler heating surface may cost less than an economizer, especially if feedwater temperature is high.

Air heating should be to not over 350 deg. F. for stokers but may be up to 600 deg. for pulverized, liquid or gaseous fuels. Air heating systems must be tight, as pressures as high as 20 in. of water may be involved and leakage not only loses heat but burdens the induced draft fan. For high rates of combustion, mechanical draft is the only solution and fans should be chosen to have best efficiency at the most efficient point of boiler operation. If peaks and valleys are short or not great, one fan may well handle the entire range but for wide or long variation from normal load, say more than an hour, special motor equipment is desirable.

Cleaning

Steam jet blowers, used regularly, will keep surfaces free of dust and assist in removing slag from boiler surfaces. Air heaters are more of a problem, especially with sulphurous gases which tend to raise the dew point. Fixed jets have been used but steam lances are usually most satisfactory and surfaces must be kept cleared of moist dust to prevent corrosion.

To keep interior surfaces clean, evaporation and deaeration have proved the most effective method where make-up is small. For large amounts of raw water, treatment to convert all solid matter into soluble form and blowing down to keep concentration below 2000 parts per million is necessary, some impurities requiring that concentration be kept even lower to avoid foaming and priming.

Deaeration should remove air and oxygen so as to leave a content of not over 0.033 c.c. per liter.

Over-all Cost

In every plant the equipment and proportions should be such as to maintain proper heat balance and secure the lowest cost per unit of output. Cost of securing various economies must be balanced against the savings to be attained. High capacity operation, with assurance of continuity, reduces the number of steam generating units but not cost in the same proportion. The saving in space may be considerable but much saving in building cost is unlikely because of added height needed.

Given careful design, adequate circulation, clean surfaces, protection of the thicker pressure parts and intelligent operation, boilers can operate indefinitely at maximum capacity, with 80 to 85 per cent efficiency and as long life as at lower rates. One of the latest examples at East River runs at 425 lb. 725 deg., feedwater 360 deg., heat release 25,300 B.t.u. per cu. ft. per hr. at 86½ per cent efficiency. It is designed for 800,000 lb. steam an hour continuous and has delivered 1,250,000 lb. for a brief period.

For industrial plants, except those the size of small central stations, load will not usually justify the cost of high capacity operation but it can be and is used where economically justifiable.

Dr. Ing. Herbert Melan Discusses

Turbines for High Pressure Industrial Plants *of the Future*

Dr. Ing. Melan, who is chief engineer of Siemens-Schuckertwerke A. G. and lecturer at the Charlottenburg Technical High School, is one of the outstanding turbine engineers of Europe. He discusses the advantages of turbines for pressures up to the 3200 lb. and feels that the simplicity, safety, ease of control and extraction and high efficiency makes this type of prime mover a favorite.

AMONG THE DIFFERENT types of power stations are industrial power plants which, besides a certain quantity of electric energy, have to supply a certain quantity of steam for process work.

Normally, the process steam is of a lower pressure than the power steam. It is obvious, therefore, that the process steam should be expanded from boiler pressure to heating steam pressure in a high pressure engine or turbine utilizing the available drop of heat by generating power.

Power available in 1 lb. of steam is greater the higher the available pressure drop, the final pressure being determined by the nature of process work it is, with respect to the combined service described above, favorable to increase the initial pressure as far as possible. From this fact arises the necessity of constructing a high pressure power element capable of economically utilizing the gain possible from the high initial pressure.

Even before the beginning of the so-called high pressure movement, that is before 1922, there were several plants with which the above points had been realized. The power element was the reciprocating engine, utilizing the pressure drop with a rather good efficiency. The exhaust steam, used for process work, however, was often considerably contaminated with oil; therefore the industry was vitally interested in the development of the high pressure turbine as a power element. Besides that, there is a circumstance essentially complicating the case of reciprocating engines from the point of view of steam flow schemes, some important alternatives of which are represented in Fig. 1.

Reciprocating engines are known to have a rather high efficiency even with small steam flows. This fact may be the main reason for which the reciprocating engine only slowly gives way to the turbine. In spite of the particular advantages of the turbine such as small space required, practically no attendance, no oil in the exhaust steam and safety of operation, the differences of efficiency in the beginning of the movement were so significant, that even the far lower installation costs of a turbine plant gave little or no economy in comparison with a reciprocating engine.

In 1923 this state of affairs was changed by the high pressure movement. Turbine constructors had succeeded in building high quality turbines able to justify the increase of pressure. The consequence was a quick development of heat economy of all industrial power plants which had the possibility of combining their power plant with their process work. In Europe nowadays, we scarcely find a plant where these experiences are not recognized.

Usually, however, the necessary power will not correspond to the process steam quantity required at the same time. In consequence of these temporal differences, the normal type of the process work turbine will be the bleeder turbine. In this type of turbine, the expansion of steam from initial to condenser pressure is interrupted at the stage of process steam pressure and the process steam is extracted. In this case bled steam quantity and electrical output can be governed independently.

If several, for instance two process steam pressures are necessary, the bleeder turbine is provided with the required number of steam extracting points, as in Fig. 1C. With respect to simplicity of service the number of bleeding points is of course to be limited, because the extraction points not only complicate the arrangement of the plant and increase its installation costs, but also reduce the efficiency within small limits by their constructive details. For this reason, two bleeding points are seldom exceeded. Usually one single extraction point is preferred as the most economic.

While, in a turbine, any number of bleeding stages can be provided, it is difficult to exceed one point in a reciprocating engine. In this case the number of cylinders must exceed the bleed points by one. Fluctuations in the bled steam quantities are less favorable than in the case of the turbine, which may be a further advantage of the latter in spite of the perhaps better efficiency.

A most favorable type of a double bled extraction unit is shown, Fig. 1D. In order to facilitate governing the high pressure part is divided in two parts, B_1 and B_2 in which the process steam quantities are expanded to different pressures. In this case a low-pressure part C working condensing and exhausting the remaining power steam into the condenser E, is provided as well.

Outside Power Simplifies Problem

If a different source of power is available it may be possible to omit the condensing part. The result is a bleeder back pressure turbine for which the above may also be applied. Its arrangement is represented, Fig. 1E. By the local separation of steam flows an undisturbed expansion can be taken care of, the bladed parts can be dimensioned according to the steam quantities most frequently required and a very good average efficiency can be obtained. This latter unit has there-

fore many an advantage in spite of the additional equipment and its higher costs.

It has already been mentioned that for obtaining economy the heat of steam must be utilized with high efficiency in the high-pressure part. The increase of initial pressure and also of initial temperatures gives an increase of the heat drop, particularly at a high back pressure.

For the design of high quality back-pressure turbines, two different points must therefore be considered: first, utilization of increased drops in shortest turbines and, second, improvement of efficiency by special blading.

Steam Flow Influences Efficiency

In former days, it had been generally observed, that for blades working in the wet steam region only, the stage efficiency has to be reduced. For a great number of stages we will get

$$(N_s) = a \times r - b\left(\frac{P_1 - P_2}{D\ H_0}\right) = N_0 - 6Z$$

for the saturated and the superheated section, the wetness of the steam is taken into consideration for the part of heat drop situated in the wet steam region by means of a coefficient f. If l_1 designs the superheated part of the expansion line (in per cent of the whole heat drop), and l_2 the other part in the wet steam region,

$$f = l_1 + \left(\frac{1 + x}{2}\right) l_2 \ \dagger$$

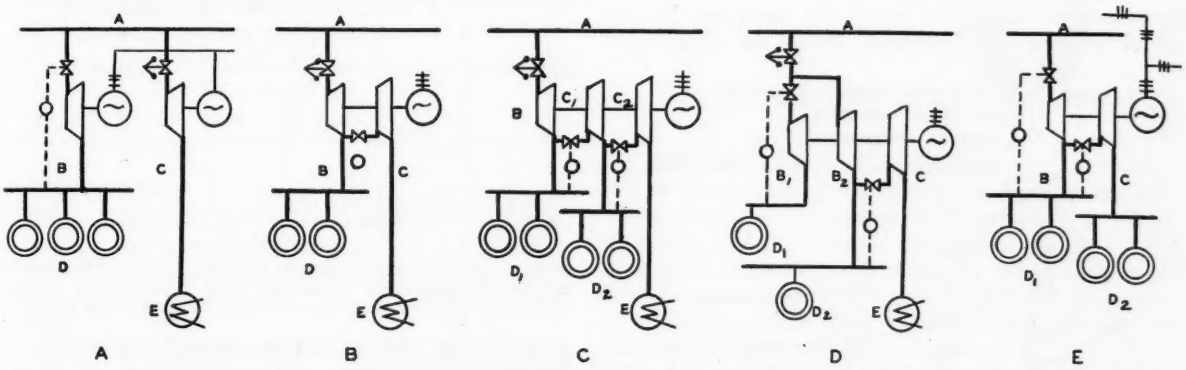


FIG. 1. DIFFERENT TURBINE ARRANGEMENTS FOR IN-DUSTRIAL PLANTS. 1A, CONDENSING AND BACK-PRESSURE TURBINE IN PARALLEL. 1B, CONDENSING EXTRAC-TION TURBINE. 1C, CONDENSING TURBINE WITH TWO EXTRACTION POINTS 1D, MULTIPLE TURBINE WITH ONEBACK PRESSURE AND ONE CONDENSING EXTRACTION. TURBINE DRIVING THE SAME GENERATOR. 1E, HIGH BACK-PRESSURE EXTRACTION TURBINE

the efficiency of a turbine (relating to steam conditions before the turbine and output at the coupling) is decreased with increased pressure and constant steam quantity and output as a consequence of losses due to clearance losses which increase with rising pressure. Steam turbine theory places the efficiency as a function of the value of u/c where u = periferial velocity and c = steam velocity. Theory shows a rather parabolic character of the efficiency curve above this value.

Results of later investigations shows that besides u/c the efficiency also depends on the so-called volume coefficient which can be derived as indicated below. Losses in the turbine depend particularly on the volume of steam. They are greater, the smaller the quantity of steam passing through the turbine.

Losses due to wheel friction, gland leakage and to poor steam distribution at partly loaded wheels depend on the reciprocal value of the specific volume v in the respective stage. The summation of the losses Sv is:

$$Sv = S\left(\frac{\text{const.}}{Dv^y}\right)^*$$

The efficiency of one single stage being

$$N_s = a - b\left(\frac{\text{const.}}{Dv}\right)$$

In the above equation a and b are constants, D being the weight of steam. In order to get a basis of comparison, it is advisable to relate the equation to points of the saturation line where x = 1. After a new theory, where x is the wetness in the last row of blades. In the equation r is the reheat factor, P_1 the initial and P_2 the final pressure. From the above equations, it is apparent that the efficiency of a steam turbine, particularly depends on the ratio of pressure difference $(P_1 - P_2)$ to the product of steam quantity (D in lb. per hr.) multiplied by the adiabatic heat drop H_0. For this ratio Z, can be substituated the reciprocal value of the average steam volume working in the blades.

Figure 2 shows on the one hand the dependance of efficiency on the Parsons characteristic and on the other hand the influence of the volume coefficient Z. The above equation gives the change of efficiency with respect to the initial pressure. When working condensing, the efficiency of a turbine is decreasing with rising pressure. With our formulae, we get the curves shown in Fig. 3, drawn for a steam flow of 40,000 lb. per hr. and for 2000 kw. For curve A the steam weight is supposed to be kept constant at 40,000 lb. per hr., while curve B is based on a constant load of 2000 kw. A comparison of the curves shows that there is a dependence of efficiency on pressure and that at constant steam weight the efficiency does decrease slightly.

With respect to the fact that practical experience is missing in the case of high pressure reciprocating engines efficiency curves developed are essentially of theoretical nature. Only at small quantity of working steam the economy of the reciprocating engine will be

*Mellanby and Kerr in Engng., Vol. 123, p. 98. The exponent "y" will be taken as about 1.

†Blownley and Warren, Americ. Society of Mech. Eng., 1924.

superior, but the difficulty with steam engines operating with high pressures should not be neglected.

Efficiencies of the steam turbines are calculated for utilizing a vacuum of 95 per cent. It seems doubtful whether at great quantities of steam the utilization of such a vacuum in a reciprocating engine would be possible. It might therefore be proposed, when steam turbines are compared with steam engines, not to regard the efficiency but to consider the steam consumption in pounds per hour. The attached curves show further the modification of the efficiency curves if the working quantity of steam is increased. With rising pressures, there is still a decreasing of the efficiency, but the curves grow flatter.

In the case of back-pressure turbines, the state mentioned above is modified as the difference of pressures is reduced while other losses are increased by the gland working with pressure above the atmosphere.

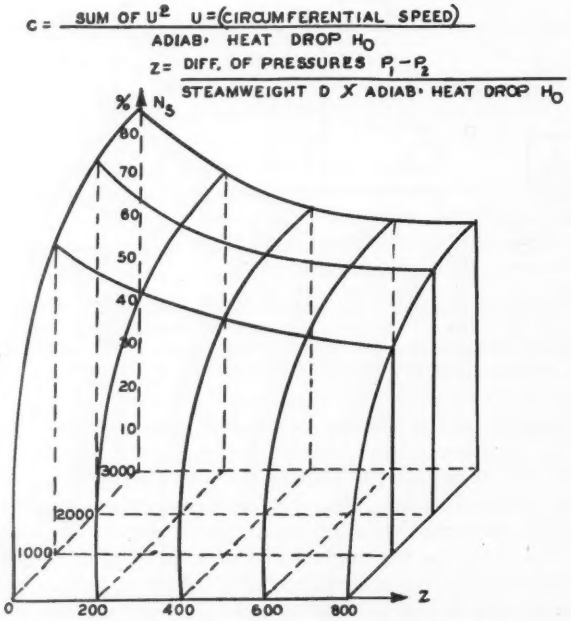


FIG. 2. TURBINE EFFICIENCY IS A FUNCTION OF THE PARSONS CHARACTERISTIC AND THE STEAM FLOW

Therefore the average volume will be a little decreased and the efficiency will be reduced. The curves of Fig. 4 were drawn for the following conditions: steam flow, 110,250 and 220,500 lb. per hr.; back-pressure = 284 lb. abs.; initial steam conditions at constant heat content, i = 1375 B.t.u. per lb. corresponding to about 497 lb. abs. and 707 deg. F. Therefore with rising pressure a varying initial temperature has been chosen.

As mentioned before, the curves show a decrease of efficiency with rising pressure according to the theory explained above. It is remarkable that a greater weight of steam improves the efficiency and reduces the falling tendency of the curves.

Briefly summarized, it may be said that the efficiency of a turbine is a function of a value depending on the difference in pressure, the adiabatic heatdrop and the weight of steam. With increasing steam weight, the losses are reduced and the efficiency is improved. The high-pressure reciprocating engine working condensing will scarcely be introduced, for the gain by the high-

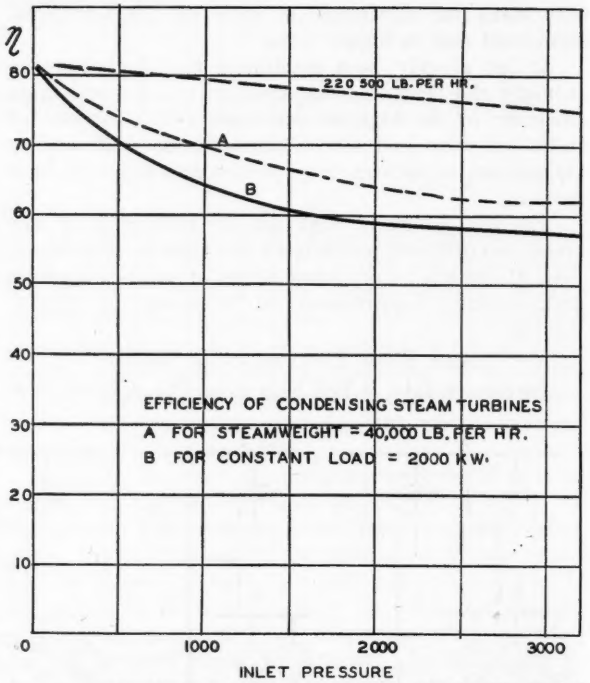


FIG. 3. EFFICIENCIES THAT MAY BE EXPECTED FROM SMALL CONDENSING TURBINES FOR DIFFERENT STEAM FLOWS AND PRESSURES UP TO THE CRITICAL POINT

pressure part will be lost by incomplete expansion in the low-pressure part.

In the high-pressure back-pressure plants with small outputs and small steam quantities the reciprocating engine may be applied and certain content of oil in the exhaust steam must be accepted. The latter being impossible at a number of industries, we nowadays find many plants with small steam quantities preferring a high pressure back-pressure turbine by reasons of practical service. In the case of complicated bleeder plants, as for instance in paper industries, factors of safety in operation and greater sensitivity in governing will justify the introduction of smaller turbines even for higher pressures.

In the case of high pressure plants with bigger outputs and bigger steam demands for heating purposes the back-pressure high quality turbine is today well adapted. Tests of several stations have shown the economy of the turbine for high pressure. Corresponding to the high pressures, there are the higher temperatures, which are easier and better handled in turbine casings than in engines cylinders.

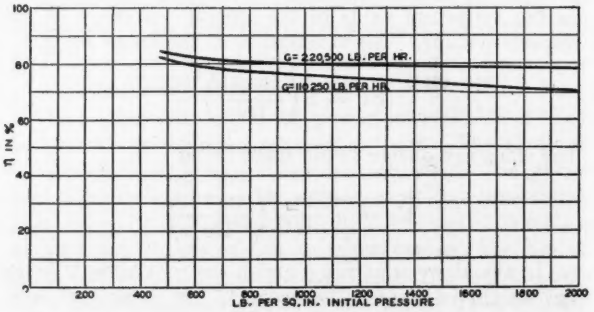
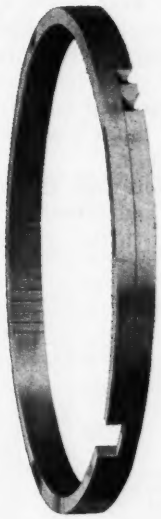


FIG. 4. EFFICIENCIES THAT MAY BE EXPECTED FROM BACK-PRESSURE TURBINES

DIESEL ENGINE UPKEEP



PART IV. PISTON RINGS IN DIESEL ENGINES REQUIRE EXTRA CARE BECAUSE OF HIGH TEMPERATURE AND PRESSURE. DETECTION AND OVERCOMING LEAKY RINGS AND FAULTY ACTION. FITTING RINGS. CHECKING OPERATION AND WEAR. OVERCOMING GAS LEAKAGE

PISTON RINGS of Diesel engines operate under severe conditions. Pressures and temperatures are high and lubrication difficult because exposed lubricant is burned away at each impulse instead of being spread out by repeated movements of the piston as in steam engines.

If gas leakage past the first ring exists, the hot gases will destroy the oil film and the lubricant here will be partially consumed. If the lubricant is of inferior grade, excessive carbonization will take place and the ring may fail by sticking in the grooves as shown in Fig. 1. With the greater clearances required in the Diesel engine, due to the high temperature of operation demanding excessive clearances at the ring points and in the grooves to allow for expansion, there is difficulty in maintaining adequate lubricant around the rings.

FIG. 1. UPPER PISTON RINGS STUCK FAST IN GROOVES HAVE NO EFFECT ON PREVENTION OF LOSS OF PRESSURE HENCE IMPAIR ENGINE EFFICIENCY

EXACTING CONDITIONS REQUIRE EXTRA CARE

Because of these special conditions, more care is taken in Diesel practice to secure tightness against leakage and more frequent inspection and cleaning of the rings are necessary. In connection with the previous article on piston upkeep, the removal and cleaning of the rings was discussed; the proper use and maintenance of piston rings will be discussed here.

The primary function of piston rings is to prevent the pressure in the cylinder from being dissipated by leakage past the piston hence fully to convert pressure to power. They also preserve the life of the piston and cylinder by avoiding the destruction of the oil film around and below the piston. The oil film must withstand a ring pressure of about 75 per cent of the cylinder compression on the top ring. This pressure is reduced as the distance from the piston head is increased.

Piston rings are usually of the simple cast-iron, snap-ring type. Eccentric rings are not favored for Diesel engines because the ends of the rings are left undesirably thin. They also cost more to make and the clearance at the bottom of the groove toward the joint is increased to a dangerous degree for the high pressure it is called upon to stand. A better method of equalizing the bearing pressure is to use concentric rings and peen their inner surfaces. This peening is done best by the manufacturer by machine, being graduated from nothing at the ends to a maximum at the point opposite the gap. A large number of thin rings is more effective than a smaller number of wide ones.

Customary types of rings have ground ends and are constrained from shifting in the groove by pins, the ring joints being staggered. For best gas seal, the joints

should be placed as far apart as possible but since greater wear of the cylinder occurs at the ring joints and such an arrangement would bring alternate joints in a line, it is best practice, for vertical engines, to distribute the joints evenly around the cylinder in pairs which are 180 deg. apart. Special forms of spring controlled rings have been tried but usually have been abandoned.

Piston rings should make gas-tight joints with both piston and cylinder. To do this, the rings must be a good fit in the cylinder and at least at one side of the ring groove. If the ring is a good fit in the groove at both top and bottom sides, no gases will pass the ring and if the gap in the ring is of minimum size, the lubricating oil which fills it acts as a fairly good seal. But both cylinder and rings wear.

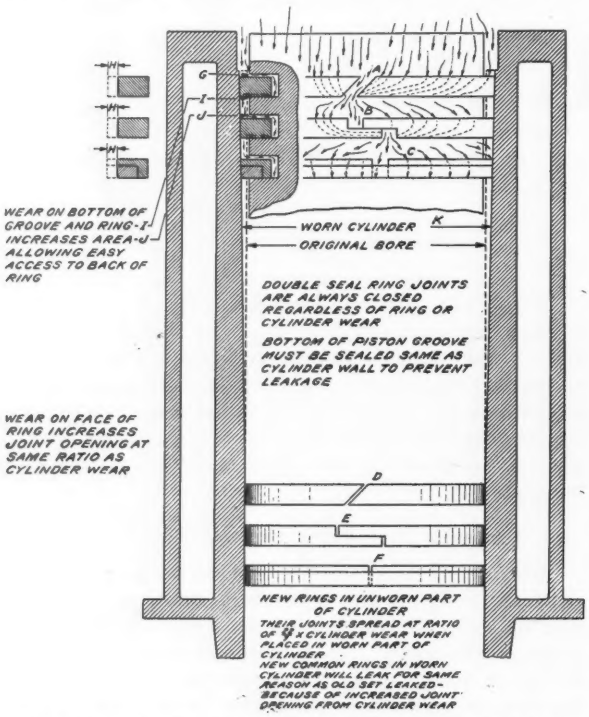

G
I
J
WEAR ON BOTTOM OF GROOVE AND RING-I INCREASES AREA-J ALLOWING EASY ACCESS TO BACK OF RING
WORN CYLINDER K
ORIGINAL BORE
DOUBLE SEAL RING JOINTS ARE ALWAYS CLOSED REGARDLESS OF RING OR CYLINDER WEAR
BOTTOM OF PISTON GROOVE MUST BE SEALED SAME AS CYLINDER WALL TO PREVENT LEAKAGE
WEAR ON FACE OF RING INCREASES JOINT OPENING AT SAME RATIO AS CYLINDER WEAR
D
E
F
NEW RINGS IN UNWORN PART OF CYLINDER
THEIR JOINTS SPREAD AT RATIO OF 8 TO 1 CYLINDER WEAR WHEN PLACED IN WORN PART OF CYLINDER
NEW COMMON RINGS IN WORN CYLINDER WILL LEAK FOR SAME REASON AS OLD SET LEAKED—BECAUSE OF INCREASED JOINT OPENING FROM CYLINDER WEAR

FIG. 2. LEAKAGE OF GAS THROUGH UNSEALED JOINTS IS STOPPED BY DOUBLE-SEAL RINGS

Since, after a considerable period of operation, a Diesel cylinder is not of uniform diameter throughout its length, the greater wear of the bore being at the top, the rings must be fitted so that the ends will not butt while in the smallest part of the cylinder. This will leave an open gap between the ring ends when the piston is at the top dead center.

Wear Increases Joint Opening

Such gaps will increase rapidly as the cylinder and rings wear. Diagonally-cut rings do not attempt to seal these joints but depend upon the staggering to prevent leakage. Step-cut rings seal the gaps partially but leave a passage under the ring as shown in Fig. 2. A dark discoloration along the outer circumference of both piston and rings, especially at the gap, is a positive evidence that the hot gases of combustion have been leaking past the rings. This is plainly shown in Fig. 3. The gases pass through the clearance between the top of the ring and the groove and out through the hole of either the diagonal or step-cut types of rings as shown in Fig. 2, the amount of leakage being dependent upon the size of the joint opening at their ends.

Detection of Leaky Rings

Leaky piston rings may be detected in a number of ways. In four-cycle, trunk type engines, the oil fog coming out of the crankcase "breather" holes indicates a blow-by. In the two-cycle crankcase scavenging engines, blow-by cannot be as easily detected, until it becomes so severe that it impairs the power or is indicated by high cooling water and exhaust temperatures. If leakage has been allowed to go this far, serious trouble usually is encountered.

An easy way for an operator to keep close check on the tightness of rings is occasionally to jack a starting piston to the top dead center, then apply the starting air in this cylinder and note the leaks which can be heard by listening at the opened crankcase directly below the cylinder being tested or by listening at the crankcase with one of the breather valves removed. It is best to do this immediately after the engine has been run at or near full load, because the piston rings are then in the condition most closely resembling that of actual operation. If considerable leakage can be heard when testing at 200 lb. pressure, it is safe to assume the leakage to be great at 600 lb.

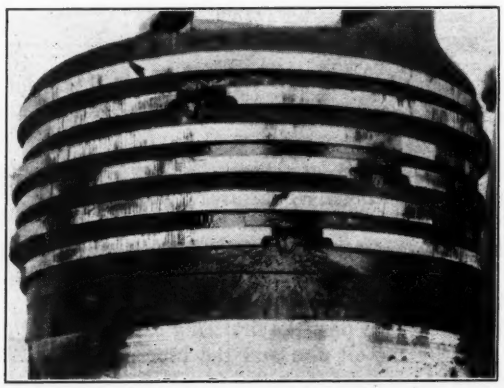


FIG. 3. GAS LEAKAGE PAST SIX ORDINARY RINGS PLACED IN USUAL STAGGERED POSITIONS

Rings made of two or more parts, notwithstanding their greater cost and complication, are being used increasingly, particularly in conjunction with rings of the ordinary type because of their ability as a seal against leakage. They are useful particularly in worn cylinders and are employed in one or two of the grooves. Such rings also serve to equalize the bearing pressure of the rings.

Operators' reports on the use of such rings indicate improved engine operation, the engines pulling a greater load with the same governor position when supplied with these rings and governing more closely and responding more readily to load changes. A reduction in fuel oil consumption was also noticed.

Fitting Piston Rings

Piston rings should be fitted to the cylinder with about a 0.01-in. gap clearance between the parted ends. The outside surface of the ring should be coated lightly

with graphite and the ring slipped into the cylinder. Contact between the cylinder and ring will remove the graphite at all bearing points. Smooth filing the ring at such points serves to fit the ring properly.

In fitting rings, the side clearance should be the least with which the rings will stay free in the groove. The lower rings should be fitted so that they will just slide freely in the grooves, the top ring usually requires

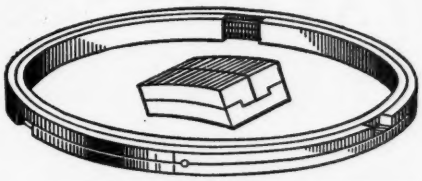


FIG. 4. A THREE-PART INTERLOCKED PISTON RING

considerable clearance to stay free if the cylinder is in good condition and the ring does not slide much. In two-cycle engines, the top ring is required to seal the ports. Shiny spots at the joints and diametrically opposite indicate that the ring does not properly fit the cylinder bore.

The depth of the ring groove should not exceed the thickness of the ring by more than 0.02 in. If greater clearance is allowed, there is greater probability of this space filling up with oil which may thicken and cause the ring to stick fast.

Snapping sounds by piston rings are caused by a fit of the rings in the grooves that is too tight. By filing the edges of the rings to give more clearance, this trouble should disappear. Detachable seats for the rings have not proven successful, as nearly all these special constructions lose their efficiency after a time by burning or sticking fast.

Checked Operation Lengthens Ring Life

Compulsory removal of pistons and rings will generally reveal them to be in worse condition than when removed for periodical attention. Rings are not saved

FIG. 5. TWO-PART RING WITH JUNCTURE ALTOGETHER IN HORIZONTAL PLANE AS INSTALLED IN VERTICAL PISTON

by methods of overhauling as often as by proper methods of operation. Rings once sprung out of true form should not be put back on the piston. Such rings will almost certainly function poorly and should be replaced with new ones.

Checking Wear

Checking the amount of wear on the outside of the ring where it bears on the cylinder liner can be done best by slipping the ring into the lower end of the cylinder where cylinder wear is practically nil and noting the amount of gap between the ends. This opening minus the original opening divided by 3.1416 will give the total wear and that result divided by two will give the amount the ring is less in depth. Depth of ring is, however, of less importance than width of gap.

It should be remembered that the gap as indicated at the lower end of the cylinder will be considerably less than that at the top of the cylinder where the cylinder wear is greater. Therefore, after trying the ring in the lower end it should be placed near the top, at the point of greatest cylinder wear and tried again, to make sure that its own tension will hold it properly against the cylinder walls at that point.

Improvement of a weak spring may sometimes be accomplished by lightly peening it on its inner surface, the outer surface lying on a hard smooth foundation during the process. This operation which tends to expand the ring and cause it to press against the cylinder walls, must be performed with great care not only to avoid breakage but to prevent distortion.

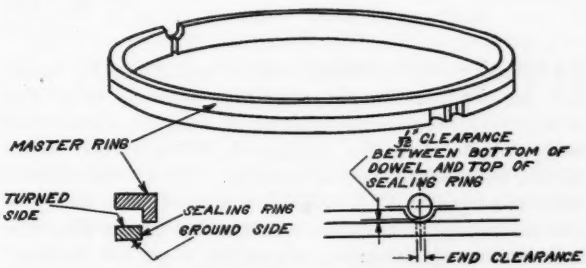


FIG. 6. CONSTRUCTION OF DOUBLE SEAL PISTON RING

Piston ring pressure is estimated to be about 5 lb. per sq. in. For best action as a gas seal, the edges of rings should be sharp but for best lubrication these edges should be rounded.

Halford Erickson, vice-president in charge of operation, Byllesby Engineering and Management Corp., announces that authorization has been granted for the installation by Northern States Power Co. of 35,000 kw. of additional generating capacity at the Riverside steam electric station in Minneapolis. The installation will consist of one 35,000-kw. turbine, with necessary condensing equipment, boilers and other auxiliaries.

Four 600-hp., 250-lb. pressure boilers will be removed and the boiler room will be extended to provide space for three boilers, each with a capacity of 200,000 lb. of steam per hour, to be installed in connection with the new turbine, as well as space for three similar boilers to be installed when necessity for additional capacity arises in the future. The present equipment in Riverside station operates at a normal pressure of 250 lb. while the new equipment will be designed for operation at 400 lb., in order to take advantage of the superior economies to be obtained by the use of the higher pressures.

Work on the substructure of the power house addition is scheduled to start November 1, 1930, during low water stages on the river; the project is scheduled for completion in the fall of 1931. Upon completion of this installation, the Riverside station will have a capacity of 107,000 kw., and with other construction now in progress, Northern States Power Co. will have total installed generating capacity of 436,060 kw.

Automatic Control of HYDROELECTRIC STATIONS *by the* All Relay System

Further Considerations of the Installation at Doris Lake, Nebraska, with Particular Reference to the Protective Features.

Part II

by E. H. Stivender

BESIDES THE FEATURE of automatically loading the machine, the control switch CS2 (Fig. 3)[1] is provided for manual control of load in which case knife switch 8Z in the circuits of 13Y and relay 41 is opened before starting the machine. The circuit of field resistor contactor 41 going through 8Z enables an operator to prevent an abnormal voltage rise in case the voltage regulator is taken out of service when the machine is started manually. Under these conditions, the voltage is regulated by means of the exciter field rheostats (Fig. 4) which are operated by one handwheel. The regulator being of the vibrating type operates on one rheostat only.

In case the line is dead and it is desired to energize it with the machine, the control switch CS1 "start" (Fig. 3) is closed, operating the master relay and starting the machine, then with knife switches 8X and 8Z open, (8 and 8Y being closed) the speed is regulated by means of control switch CS2 and the oil switch is closed by CS3 (Fig. 4).

Should it be desirable to synchronize the machine with the line independently of the float switch, knife switches 8, 8X and 8Z are closed and the starting procedure is initiated by means of control switch CS1 (Fig. 3) and the succeeding sequence of operations occurs in the same manner as explained for automatic starting in the foregoing article.

Stopping

For normal shutdown at low water, all knife switches being closed, the low water switch 1 closes, shunting the coil of master relay 3 which opens its contacts, interrupting the holding circuit so that it remains open.

The Gates Close

With the opening of the master relay, the governor solenoid 65 and auxiliary master relay 3X are deënergized; however, the control bus BP2 remains energized through an auxiliary switch 52, which is closed while the circuit breaker is closed. When the governor solenoid is deënergized, the mechanical timing device on the governor requires the gates to close slowly, thereby enabling other units on the system to assume the load.

Machine Disconnected from the Line

As the gates arrive at the no-load position, limit switch 33 closes completing the circuit of the circuit breaker trip coil 52T through a "break" contact of 3X and an auxiliary switch on the circuit breaker, hence opening the breaker.

When the breaker is opened, auxiliary switch 52 in the brake solenoid circuit opens, deënergizing the brake solenoid BM (Fig. 3) which operation releases the clock mechanism of the brake timer; just before the gates completely close, the timer starts on the brake valve operation so that shortly after gate closing (time allowed for speed decrease) the brakes are applied and then released automatically.

The opening of the circuit breaker 52 disconnects the battery from the control bus BP2, thereby deënergizing the rest of the control.

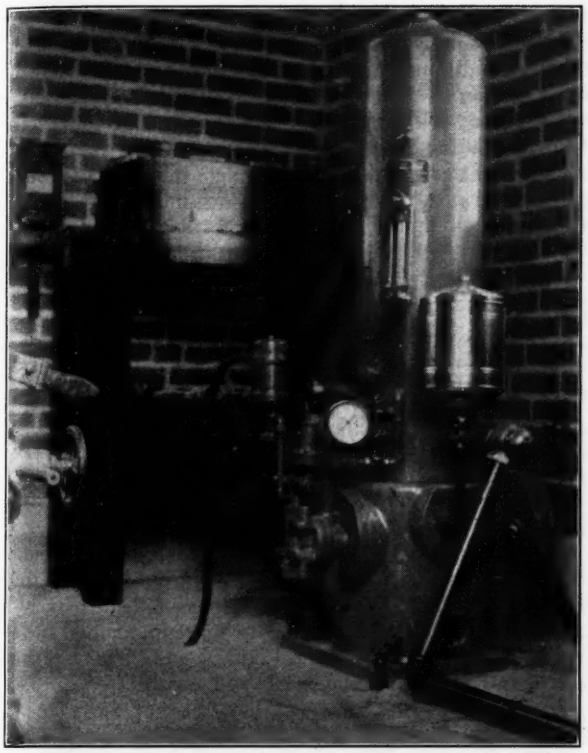
As circuit breaker 52 opens, an auxiliary contact is made which completes a circuit through 92L and 92Z (Fig. 3), a switch on the governor which is closed above the full speed-no load position of the synchronizing motor 92. This runs the motor back so that when the machine is again started the synchronizing motor will be in the 60-cycle position.

Protective Features

(1) Overspeed

Failure of control voltage to the governor flyball motor or sudden loss of load are usually the causes of overspeed. Should the machine overspeed for any reason, device No. 12, the overspeed switch on the generator shaft closes at 115 per cent normal completing the circuit through auxiliary relay 51X (Fig. 3). A "break" contact of 51X opens the circuit of the governor solenoid 65, a "make" contact trips the circuit breaker, another operates the annunciator (described later) and the other holds the relay closed through a limit switch on the governor 33Y, which opens at and below no-load position of the governor gates; hence, when the gates are closed to no-load position (65 being deënergized) relay 51X opens—the overspeed switch 12 being now open—and 65 is again energized, the governor assumes

[1] Figures 3 and 4 referred to in this article appeared in Part I in the July 1 issue.



GOVERNOR PRESSURE TANK AND CONTROL BATTERY AT DORIS LAKE STATION

control and the synchronizing equipment acts again to connect the machine to the line.

(2) Overload

Induction overcurrent relays 51 operating through current transformers (Fig. 4) act on relay 51X in the same manner as the overspeed switch, thereby causing the same subsequent operations as described above. Since the line must be energized at full voltage in order for the synchronizing equipment to operate, the circuit breaker will not close until the cause of overload on the line is removed. Should the overload not be removed for some time, the machine will come back to normal speed and remain (owing to the action of 92Z the machine will not go over full speed) for a short time, when it will be locked out by relay 48 acting on 30.

(3) Overheated Windings

Thermal overcurrent relays operating from current transformers (Fig. 4) in the generator leads are provided to shunt the master relay coil when excessive currents of long duration occur but are not of sufficient magnitude to operate the induction overcurrent relays (which have high current settings and short time settings). These relays have approximately the same temperature characteristics as the machine and when the time allowance is up (corresponding to the setting of the relay), the master relay is opened and the machine is shut down.

The Allis-Chalmers Mfg. Co. uses the Westinghouse type "BA" thermal overload relay for this purpose.

(4) Low Oil Pressure

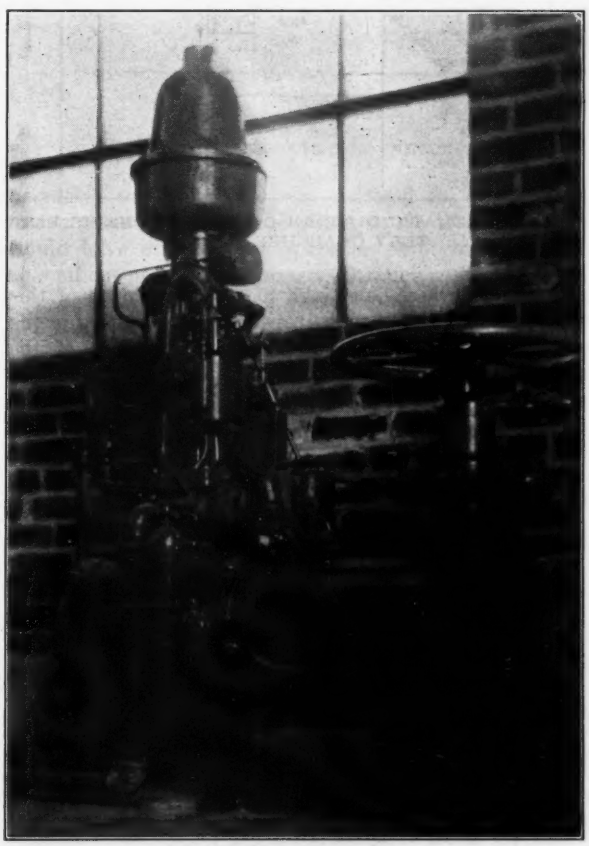
When the governor oil pressure drops below a safe operating value, the oil pressure relay 63 opens the circuit of master relay 3, causing shut-down as under normal operation. The machine cannot be restarted until the pressure is again normal.

(5) Failure to Synchronize

Should the machine fail to synchronize in five minutes, due to the line being dead, unstable speed of the machine, varying frequency and voltage of the line or other causes, timing relay 48 will operate releasing the mechanically latched in switch 30 (described later) tripping out the circuit breaker and shutting down the machine. This device prevents waste of water and undue wear of the equipment. It is a General Electric Co. type MC. When the coil (Fig. 3) is energized by completing the circuit of control bus BP2 through contactor 3X, its core is drawn in connecting the motor reduction gear mechanism to the movable contacts, which start traveling slowly. The motor is energized through a circuit breaker auxiliary switch and a "break" contact of the relay. When the time limit is up, one contact closes, operating the lock-out relay 30 and another opens, breaking the motor circuit, and as 3X opens (actuated by a "break" contact of 30 in the master relay circuit) the coil of 48 is deënergized and its core drops out, resetting the relay for a future starting cycle. If the circuit breaker closes before the time is up, the motor circuit is opened by an auxiliary switch.

(6) The Lock-Out Features

Protective measures, such as generator differential relay operation and overheated bearings, which justify the immediate disconnecting from the line and subse-



THE GOVERNOR BALL HEAD AND MECHANISM

quent stopping of the machine, energize the trip coil of the normally latched-in contactor 30. This contactor is manufactured by Cutler-Hammer, Inc., and has one "make" and three "break" contacts; that is, when device 30 operates, due to the circuit of its coil being closed and releasing the latch, the following operations succeed immediately: The master relay coil circuit is opened (Fig. 3), the operating coil circuit of 30 is opened, a resistance is inserted in the exciter shunt field (Fig. 4) and the "make" contact closes auxiliary relay 30Y (Fig. 3) tripping the circuit breaker. Therefore the operation of 30 performs complete shut down by opening the circuit breaker first and afterwards shutting down the machine, while the float switch and control switch CS1 bring the machine to idling position before opening the circuit breaker.

Device 30, being hand reset, necessitates the presence of an operator before service can be resumed, for

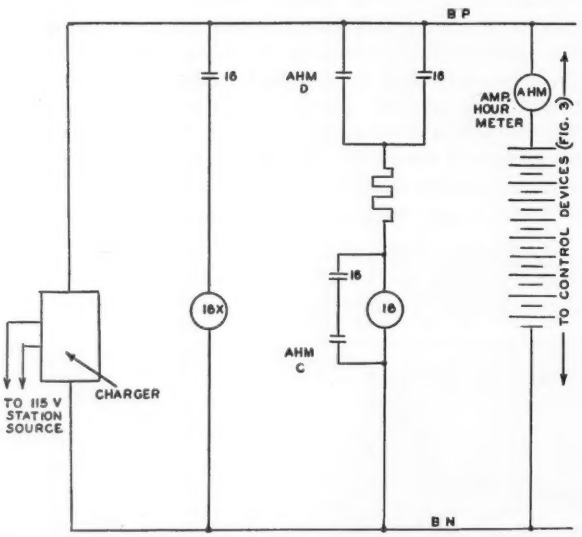


FIG. 5. SCHEMATIC DIAGRAM OF THE AUTOMATIC BATTERY CHARGING SYSTEM

any condition serious enough to cause operation of this relay requires a thorough inspection before starting the machine again. Being mounted on the front of the switchboard, it can readily be tripped by hand should emergency conditions require immediate shutting down of the station manually.

(7) Local Short Circuits

Differentially connected current transformers in the generator neutral leads and line leads (Fig. 4) are connected to Westinghouse type CA ratio—differential relays mounted on the switchboard. The operation of these relays energizes device 30 should a short circuit occur within the generator or generator leads. Owing to their construction, they require the current of both sets of current transformers to energize corresponding coils in each relay, allowing an instantaneous operation setting and a very sensitive unbalance setting, thereby giving more dependable protection than ordinary induction time element differentially connected relays since relatively small unbalances such as partial short circuits render immediate removal from service of the machine.

(8) Overvoltage

Excess voltage arising from voltage regulator failure or line conditions causes the machine to be shut down by operation of device 30. The Westinghouse type CV voltage relay 59 (Fig. 2) is energized from a potential transformer in the generator leads. It is an induction time element relay and set to complete the lock-out relay coil circuit at 20 to 30 per cent above normal generator voltage.

(9) Overheated Bearings

For immediate stopping of the machine in case of overheat of a bearing, bearing temperature relays 38 (Fig. 3) are placed in each bearing which operate device 30 should the temperature rise above the safe operating value, namely at 65 deg. C. This device is an Allis-Chalmers "Thermalarm" relay, being screwed into a tapped hole in the bearing housing and inserted as a plug is very inconspicuous. Terminals on the end provide means for connecting to the protective apparatus.

A sealing compound inside the relay allows the contacts to close at its melting temperature, owing to the influence of a spring. Resetting is accomplished by removing the relay and heating to melting temperature, then the contacts are forced apart and held by the compound after the relay cools sufficiently.

(10) Bearing Oil Failure

The thrust bearing is of the roller type and runs immersed in oil; it is self-alining and requires no upper guide bearing, the lower guide bearing is lubricated by an independent oil circulating system, possessing a sight flow indicator with contacts 38X (Fig. 3) which close when circulation falls below the same operating point. These contacts complete the circuit of auxiliary relay 40X (Fig. 3) and if the oil should fail while the machine is on the line lock-out relay 30 is operated through auxiliary switch 52 (Fig. 3); 40X is a temperature time element relay which operates in approximately 2 min. It is provided to lock out the machine by operation of device 30 should the bearing oil fail to flow sufficiently shortly after starting the machine. 40X cannot operate when the machine is shut down (although 38X will be closed) since it must be energized through the auxiliary master relay 3X (upon which the machine depends for shutdown).

(11) Field Failure

The relay 40 (Fig. 4) which is in series with the generator field is set to open its contacts when the field, on increasing excitation, reaches a value below full voltage at idling speed. Its contacts (Fig. 3) are connected similar to those of bearing oil failure relay 38X and perform the same operations, namely to operate relay 40X should the field fail to build up fast enough to energize the governor flyball motor to prevent overspeed, and to open the circuit breaker immediately should the field fail while the generator is on the line.

(12) The Annunciator 30X

For immediately indicating operation of one or more of the various devices an annunciator composed of telephone relays and nine small telephone lamps is mounted on the switchboard. In Fig. 3 each annunciator relay coil and its corresponding contact is designated by

"30X" with the suffix "38," "40X," "59," etc., corresponding to the protective apparatus whose operation will be indicated by the lighting of a lamp bearing the number of the device.

When device 48 or 49 operates coil 30X48 or 30X49 is energized, closing the contacts of its corresponding relay which in turn energizes an adjacent relay coil (marked 30X6—30X9 (Fig. 3)) through lamp 48—49. The contacts of this second annunciator relay on closing complete an independent circuit through the lamp and reset the push-button which holds the relay 30X6—30X9 closed and hence the lamp 48—49 burning until interrupted by operation of the reset push-button.

Device 51X operates annunciator relay coil 30X51 and lights lamp 12—51 (overspeed—overload), the relay remains energized through its own contacts after 51X has opened. This enables the operation of overspeed or overload relays to be ascertained even though the machine has resynchronized and is running normally when the plant is visited. Bearing oil failure relay 38X deënergizes its annunciator lamp on opening its contacts (when oil circulation starts).

Should device 40 or 38X operate while the machine is on the line, annunciator lamp 40 will light and remain so until reset by the push-button.

Devices 87, 59, 38, and 40X indicate on corresponding lamps similarly to 40 and 38X on lamp 40.

(13) The Voltage Regulator

The voltage regulator used in this installation is the Westinghouse type AB-2 (vibrating). Alcohol is employed in the dashpots instead of the usual distilled water since the plant will at times be subjected to temperatures as low as 32 deg. below zero. For economy of space, the regulator element is mounted behind the main switchboard in a readily accessible position.

Although operating on the exciter field rheostat, this regulator does not employ a d.c. operating coil and instead employs two a.c. operating coils, one for vibrating and the other for indicating the line voltage. In other words one coil armature intermittently vibrates, short circuiting the rheostat, and having a definite period of vibration for a certain voltage to be regulated, while the other coil is directly connected to the potential transformer and determines the raising or lowering of machine voltage by raising or lowering the main contacts which the first coil intermittently opens and closes, therefore increasing or decreasing the period of vibration of the shunt across the exciter field rheostat in accordance with a.c. voltage conditions.

The regulator is therefore not affected by high exciter voltage arising from abnormal exciter field excitation during low voltage surges on the power line.

Battery Charging

Figure 5 is a schematic diagram of the automatic battery charging scheme which permits the battery to be at all times sufficiently charged; the only attention necessary being that of usual battery maintenance, mostly the addition of distilled water periodically. The battery and equipment consists of an Exide battery charged by a Rectigon charger and controlled by a Sangamo ampere-hour meter.

The ampere-hour meter is specially constructed for this service, that is while charging, the indicator on the dial reads less ampere-hours than the actual ampere-hours passed and while discharging it reads correctly. Therefore since the contact movement is proportionate to that of the indicator, the battery will receive about 20 per cent more ampere-hours than it has delivered which makes allowance for its efficiency characteristics.

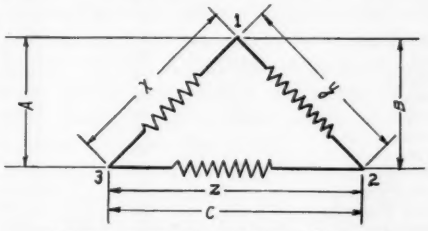
When the meter reaches the limit of discharge, contact AHM-D (Fig. 5) closes, completing the circuit of the battery charging relay coil 16 which on closing holds itself in by an auxiliary contact in parallel with D and also energizes 16X, the relay furnishing a.c. power to the charger. The meter now reverses and on reaching the limit of charge shunts out coil 16 by AHM-C through a "make" contact of this relay, indirectly opening 16X until the discharge cycle is again completed.

In another article, the action of the frequency matching relays and the automatic synchronizer will be discussed.

Resistance Measurements of Transformer Windings

By C. O. von Dannenberg

RECENTLY, the writer had occasion to determine the individual resistances of the phases of a three-phase transformer when only the three terminals at the junction points of the windings were available. It was



CLOSED, THREE-CIRCUIT WINDING

necessary to do this the way referred to, since direct measurement of each of the phases at the terminal board would have involved the operation emptying considerable oil out of the transformer. Strange as it may seem, a search in a number of electrical handbooks did not indicate any direct formula which could be applied to the case involved. While it is nearly always possible to obtain this information by direct measurement, since the terminals of each phase can be reached and disconnected from the others, a case like the one cited is not uncommon under emergency conditions.

The appended diagram indicates a closed three-circuit winding, 1-2-3, made up of three separate circuits x, y and z; resistance measurements are taken between terminals 1 and 2, 2 and 3, and 1 and 3, either by bridge or drop of potential, i. e., volt and ammeter, method. The resistances so measured are denoted as A, B and C; substituting these values in the following equations will give the desired phase or separate resistance values:

$$x = \frac{2AB + 2BC + 2AC - A^2 - B^2 - C^2}{2B + 2C - 2A}$$

$$y = \frac{2AB + 2BC + 2AC - A^2 - B^2 - C^2}{2A + 2C - 2B}$$

$$z = \frac{2AB + 2BC + 2AC - A^2 - B^2 - C^2}{2A + 2B - 2C}$$

The foregoing formulas are not as formidable as they appear, since the numerator is the same in each and the denominator a very simple quantity to obtain.

Obviously, the formulas are applicable for use in connection with the resistance measurements of any three-circuit type of winding similarly connected and are of greatest value in an emergency situation.

Latent Heats of Foods*

By A. H. Cooper

CENTRALIZATION OF THE industrial population has led to the necessity of specialized transportation and storage facilities for handling foodstuffs. Since the great bulk of foods is highly perishable, the transportation and storage of foods is not only hazardous but result in a tremendous waste due to spoilage before it can be distributed into channels for consumption.

LATENT HEATS OF FOODS

Food	Average percent of water present	Latent heat, Btu.
Apples	84	120.6
Grapes	75	107.2
Strawberries	90	129.7
Oranges	87	124.4
Pears	63	90.0
Butter	10	14.7
Cheese	35	49.9
Eggs	73	105.0
Milk	87	125.0
Green Beans	83	118.9
Beets	90	129.4
Cabbage	91	129.5
Carrots	86	122.6
Celery	94	134.4
Lettuce	94	135.8
Onions	88	126.7
Peas	75	107.6
Irish Potatoes	79	113.6
Sweet Potatoes	71	102.0
Bacon	20	28.2
Beef	71	102.0
Fish	76	108.8
Mutton	67	95.5
Pork	46	65.5
Veal	63	90.5
Ice	100	143.4

In the line of perishables from the farm, fresh shipment under refrigeration has already revolutionized the whole scheme of things. But now we are hearing more and more about frozen packed berries, eggs, fish, and meats. Perhaps it will only be a step until we find frozen pound packages at every corner grocery store just the same as canned goods. Again, as foods are produced in quantities in certain seasons of the year which exceed the possibility of consumption in the short period during which the markets are flooded, the storage of foods has become one of our most important economic problems.

In recent years there has been an increasing use of cold storage for the freezing of fish and other meat products during heavy seasons. Why is not quick freezing of all such products the remedy?

*Abstract of a paper presented at the meeting of the American Society of Refrigerating Engineers, Atlanta, Ga., May 7-9.

As a result of the recent progress towards frozen foods as a method of stabilizing and preserving the food supply, this study of latent heats of frozen foods has become of interest and importance. It has its value in relation to present American practice, or contemplated practice, of quick frozen foods.

The procedure followed in obtaining the values of latent heats of foods is as follows: A weighed amount of water was placed in the calorimeter and the temperature taken. Weighed samples of various foods, which were frozen and kept at a definite temperature, were added to the calorimeter and the temperature drop of the water noticed.

To diminish the actual loss or gain of heat by radiation, a double-walled vacuum bottle is used, containing a weighed amount of water. By observing the change in temperature of the water accompanying the change of state, and, from experiment finding the heat capacities of the calorimeter and its accessories, it is possible to calculate the amount of heat change.

Theoretically, the latent heat can be calculated as follows:

$$\text{Latent heat} = \{(T_1 - T_2)\ W_1 - [T_3 - T_0\ (W_2 \times H_1) + T_2 - T_0\ (W_2 \times H_2)]\} \div \{W_2\}$$

Where

T_1 = Initial temperature of water in calorimeter.
T_2 = Final temperature of water in calorimeter.
W_1 = Weight of water in calorimeter.
W_2 = Weight of substance added.
T_3 = Temperature of substance added.
T_0 = Freezing temperature.
H_1 = Specific heat of substance below freezing.
H_2 = Specific heat of substance above freezing.

However, due to radiation, and temperature change of the water, some heat is obtained from the atmosphere, and the walls of the calorimeter. In order to estimate the amount of heat gained in this way, water of various pre-determined temperatures was added to the calorimeter, which was kept at various temperatures, and the temperature change of the water noticed. From these values, a curve was developed showing the relation between heat losses and temperature changes.

The latent heat of fusion of a substance is the quantity of heat which must be imparted, at constant temperature, to unit mass of the substance in the solid state in order to effect the change of state from solid to liquid.

To change one pound of ice from ice at 32 deg. to water at 32 deg. F., will require 143.4 B.t.u. of heat. Or, using different units, to change one gram of ice from ice at 0 deg. C. to water at O deg. C., will require 79.7 calories.

The table of values shows the latent heat of fusion which have been experimentally determined in this preliminary report. This may be plotted to show a straight line of computed values on the basis of latent heat of fusion of water at different percentages. The proximity of the experimental values to the computed values show that perhaps if the experimental error is eliminated, the values will fall on the straight line.

For all practical purposes the latent heat of the food can be computed by multiplying the percentage of water present by 143.4, the latent heat of fusion of water in the food.

Operating Code Manual for Power Plants

N. E. L. A. Code for Operating Reciprocating Engines

CONSIDERING the total amount of electrical power generated, reciprocating engines do not play as important a part as they once did but they still form a large part of the generating capacity of the smaller plants. Their operation demands somewhat different treatment from turbines and the following paragraphs applying to Corliss engines form the basis of operating directions which can be amplified to meet individual conditions.

Starting Corliss Engines

1. When ready to start, notify the switchboard operator that the machine is ready to be warmed up.
2. After receiving affirmative reply, see that all drains from the cylinder are open.
3. See that the drain and trap above the throttle valve are open.
4. See that the main exhaust valve is open.
5. If a compound engine, see that the receiver is drained.
6. See that the wristplate is unlatched from the eccentric rod hook.
7. See that oil is running to the bearings of the engine.
8. See that the crank and crosshead pit drains are open and free.
9. See that the cranks, crossheads and other movable parts are not obstructed by any foreign material.
10. See that the wristpins, crankpins, eccentric straps and wristplate pins are tight.
11. See that the valve gear nuts, etc., are tight.
12. See that the crank is in such a position that the engine will start readily.
13. See that the governor belt, when used, is in good condition and free from oil.
14. Examine all gages.
15. Oil the governor spindle and see that the dashpot has the necessary amount of oil.
16. Start the circulating, air and hotwell pumps, and get partial vacuum in the condenser.

(Note: Regulate hotwell pump so that proper water level is maintained above pump suction.)

17. See that the governor is hooked up on the safety pin.
18. Place the bar in the wristplate of the engine.
19. Open the bypass valve, or crack the throttle, admitting steam alternately to each end of the cylinder, warming it up and getting all the water out of the valve chest and cylinder.

(Note: Shifting of valve gear to permit steam to enter alternate ends of cylinder shall be done with throttle or bypass valve closed, due to the wear and tear on the crankpins and boxes when this operation is performed under steam pressure.)

20. Open the throttle valve farther until the engine revolves slowly, then engage the wristplate with the eccentric rod hooks.
21. See that the lubricator and oiling system are in operation.
22. Notify the switchboard operator that the machine is ready for operating speed.
23. After receiving affirmative reply, open the throttle slowly and close the bypass valve, noting that the engine comes up to proper speed.
24. See that the safety pin of the governor is in a correct position to operate, should the governor belt break.
25. Close the drains.
26. Signal "Load" to the switchboard operator.
27. As the load comes on, bring the vacuum up to normal.

Shutting Down Corliss Engines

1. After receiving the signal "Stand By" from the switchboard operator, answer it.
2. After receiving and answering the signal "Stop" from the switchboard operator, close the throttle slowly until the engine comes almost, but not quite, to a stop.
3. Reverse the safety pin of the governor so that the governor will not drop to the lowest point.
4. Place the bar in the wristplate.
5. Disconnect the wristplate from the eccentric rod.
6. Operate the wristplate by hand with the bar so that the engine will stop with the crank in starting position.
7. Move the wristplate to central position so that the exhaust valves are closed.
8. If the engine has a double eccentric, trip the steam valves by hand when the wristplate is in a central position, so that the steam valves may be closed and lapped. (Note: A test should be made periodically by leaving the governor safety pin in the running position when shutting the throttle valve, to see that the safety device is in working order.)
9. Shut down the circulating, air and hotwell pumps. (Note: If jet condenser is used, close off injection water just before closing throttle valve and allow air or wet vacuum pump to run until engine stops, thus obviating, to some extent, the possibility of water being forced by atmospheric pressure through air or wet vacuum pump into low pressure cylinder in the event of displaced or defective valves in the pump.)
10. Shut off the oiling system.
11. Open the drains.

Office building 100 per cent electrically welded, 19 stories high, the tallest yet to be undertaken, is now being constructed for the Dallas Power & Light Co. in Dallas, Texas. Construction began March 15. Excavation has been completed and footings have been set. The first steel was expected on the job by July 1. Steel fabrication and erection will be done by the Mosher Steel & Machinery Company, using General Electric welding equipment. Lang and Witchell are the architects, and R. L. Rolfe is structural engineer for the building. Frank P. McKibben has been retained as consulting engineer in connection with the welding.

New orders for 1017 steel boilers were placed in April, 1930, as reported to the Department of Commerce by 81 manufacturers, comprising most of the leading firms in the industry, as compared with 972 boilers in March and 1706 in April, 1929.

Value of a Tailwater Reservoir

ANALYSIS OF DATA TAKEN AFTER DREDGING SHOWS THAT INCREASED HEAD BENEFITS INTERMITTENT OPERATION. BY RALPH SHAW

DATA TAKEN to determine the effect of dredging below a hydroelectric plant revealed the fact that the increase in head during the period of intermittent operation was the result of two new conditions. The first and anticipated was the reduction of head-loss due to the enlarged channel and the removal of controls.

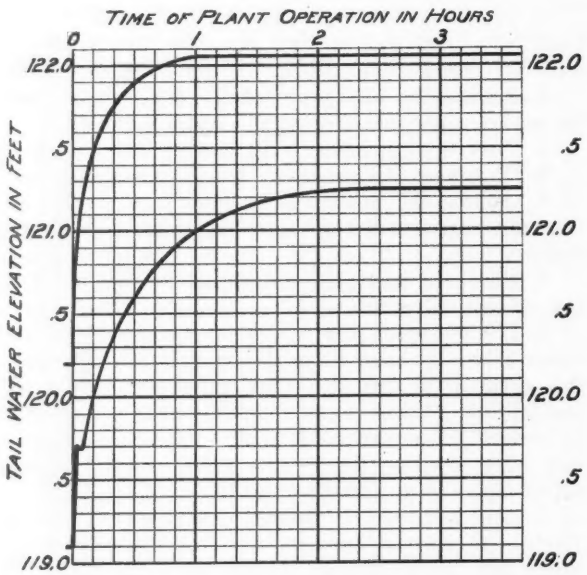


FIG. 1. RELATIONS BETWEEN TAILWATER ELEVATION AND TIME. UPPER CURVE, BEFORE DREDGING; LOWER CURVE, AFTER DREDGING

The second was the increase in reservoir capacity below the plant. The data as obtained made it possible to determine the value of the increased head due to the added reservoir capacity and show a definite value of a reservoir below the plant for a period of the year during which the operation was intermittent.

An examination of conditions prior to dredging showed that the tailwater was held up by a series of controls extending 1200 ft. down stream from a point about 800 ft. below the plant. The dredging was begun about 500 ft. below the plant and continued down stream through the series of controls. It was then found that material was being carried from immediately below the plant into the dredged section. To maintain the full value of the dredged area, it was decided to clean out the stretch immediately below the plant.

The gain in head resulting from the decrease in losses amounted to 0.8 of a foot, as shown in Fig. 1. It is apparent from the curves in the same figure that the period of time required to build up the tailwater was increased from 60 min. to about 140 min. It is this more gradual rise of the tailwater that yielded noticeable and unexpected results during intermittent operation. It was found that during the first two hours of operation the average gain in head was about 1.1 ft. or 37½ per cent more than was gained by reduction in losses. Because the summer flow of the stream on which this plant is located is sufficient for two daily operating periods of about four hours each, the gain in head as realized was approximately 19 per cent greater than was anticipated.

The curves in Fig. 2 are made from data of tailwater elevations taken at various times during the dredging. To show more clearly the difference in time required to build up the tailwater to a stable elevation, the curves are all plotted with the same final elevation. Before the dredging, the building-up period of the tailwater was about one hour, almost an hour and three-quarters with the dredging half completed and a full two hours for the two remaining cases. A comparison of the two lower curves shows the effect of removing the bars immediately below the plant. The removal of the bars in no way affected the final elevation of the tailwater and the only benefit expected from their removal was that of preventing a filling of the lower dredged section. However, as it developed there is some slight benefit realized during the low flow period in increased energy output from the plant.

It is to be borne in mind that the increase in reservoir capacity below the plant is of value to intermittently operated plants only. During the period of continuous operation the increased head results entirely from the reduction of losses in the tailrace. However, the intermittent operation is for the purpose of cutting down the daily peak on the steam plants and tends to increase the steam plant load factor and consequently its efficiency. The value of the tailwater reservoir capacity in the reduction of operating costs depends so much upon conditions peculiar to each situation that a definite general statement cannot be made.

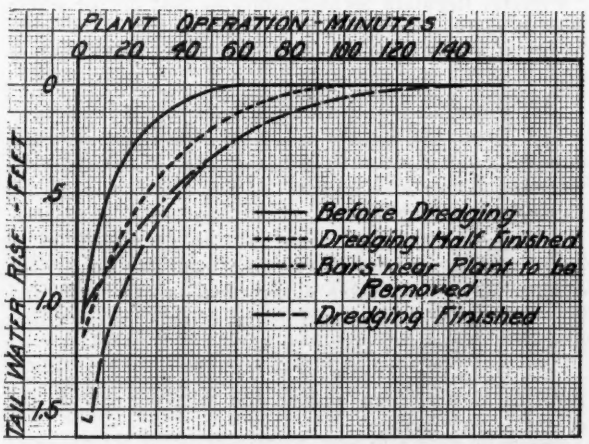
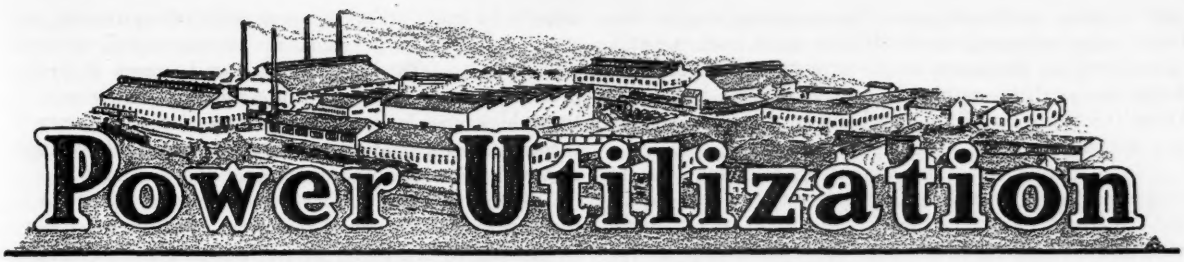


FIG. 2. RELATIONS BETWEEN TAILWATER RISE AND TIME UNDER VARIOUS CONDITIONS



Power Transmission with Short Center Drives

SILENT CHAIN, V-BELT, FLAT BELT. DETAILS, SPEEDS AND EFFICIENCIES. BY R. SALMONSEN*

MODERN CONDITIONS in the mechanical power transmission field require a transmission medium that combines high efficiency, high economy in cost as well as maintenance, and permits of maximum conservation of floor space.

This requirement has led to the development of a variety of short center drives, each of which has distinct advantages in certain types of work. Experience has clearly shown that no one particular transmission is best suited for all conditions. Only by careful analysis of all of the operating conditions in each particular case, together with past experience, can selection of the proper drive be made.

It is hoped that the following general discussion of the more important short center drives will be of assistance to users of transmission equipment in such selection.

SILENT CHAIN DRIVES

This type of drive, typified by Fig. 1, employs a toothed metallic transmission medium. It is especially adapted for slow speeds, where motion must be positively transmitted and where considerable power per inch width of the driving element is required.

Inherently it is inelastic, although there is a limited amount of play in the component parts of the chain and due to the special construction of the joints.

Special elastic provision can be made by introduction of springs in the rims of the sprockets but are used only on special drives where frequently fluctuating loads are encountered. Where the driven machines, such as compressors, are lacking in flywheel effect, so that a uniform rotative speed is not obtained, spring-equipped sprockets may be used in an endeavor to smooth out the whip of the chain due to the uneven stresses resulting.

To protect the driving and driven machines, when chain drives are used where peak or shock loads are encountered, shear pins, designed as the weakest part of the system, are mounted in the sprockets to fail first in the event of a dangerous overload or peak.

In laying out chain drives where periodical load variations occur, it is recommended to use a conservative rating for the chain. Depending upon the maximum momentary peak loads, the frequency with which such peaks occur and the time interval in which they occur, only from 50 to 80 per cent of the catalogued ratings should be taken.

Efficiencies of 98.2 per cent are claimed for silent chain drives while new, this figure being understood as the actual result of a laboratory test run. As the chain wears, this value will naturally be lower. This value of efficiency is for the chain drive proper and includes no bearing friction in the driving and driven machines, incidental to the power transmitted and to the weight of the sprockets and the chain.

Chain speeds of from 1800 to 2000 ft. per min. are generally recommended. Speeds in excess of these will result in considerable noise and deterioration, requiring adjustment as the chain wears to prevent the possibility of sufficient slack occurring so the chain will climb the teeth.

Because of bearing friction losses in driving and driven units due to the high tangential force and correspondingly high resultant bearing pressures, incidental to the comparatively low chain speeds, to the weight of the sprockets and the metal chain and to the chain tension, it will generally be found necessary to use three bearing motors or generators on units from 75 to 100 hp. and up.

Under favorable conditions, reduction ratios of as high as 15 to 1 have been used in one reduction. Com-

FIG. 1. TYPICAL 40-HP. LINK-BELT CHAIN DRIVE

*M E. Lenix Dept., F. L. Smidth & Co.

pact layouts can be obtained, the minimum center distance being ordinarily made slightly more than one-half the sum of the diameters of the sprockets. Where large ratios are used, the minimum center distance is usually about 0.8 times the difference between diameters of the two sprockets.

Chain drives have the advantage of being able to run almost equally well in either direction. It is advisable to avoid drives vertical or nearly so, particularly where the smaller sprocket is the lower one, as the weight of the chain tends to drop it from its proper engagement with the smaller sprocket.

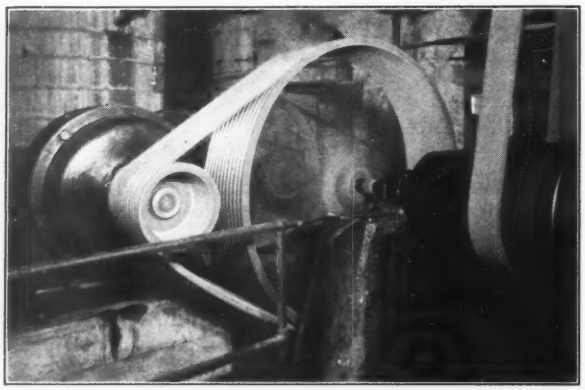


FIG. 2. 75-HP. MULTIPLE TEXROPE DRIVE

Multiple V-Rope Drives

This type of drive, typified by Fig. 2, employs a number of trapezoidal shaped or V-belts, of fabric or rubber, as the transmission medium. Power is transmitted by the friction of the trapezoidal belt section against the sides of the sheave groove.

Proper construction of the V-belts is vitally important in this type of transmission. For instance, belts manufactured round and molded into the trapezoidal shape may, when under load, have a tendency to regain the original form, which would result in inefficient transmission, as the load would be carried by only a comparatively small section of the sides of the V-belt. Correct sloping of the sides of the V-belt as well as the sides of the sheave grooves is also important, as otherwise, the rope may slip or may sink too solidly into the groove so that the belt will rub against the bottom of the sheave groove. Either condition would cause undesirable abrasion of the belt.

V-belt drives offer compactness in arrangement as the center distance can be made such that there are only a few inches between the rims of the driving and driven sheaves. The drive possesses elastic features common to rubber or fabric belt drives. Motors or generators for this type of drive should always be equipped with slide bases to facilitate the adjustment of the tension in the belts at the proper value. In cases where the shaft centers are fixed, as on an engine driving a blower, belt wrappers or flexible idlers have been installed in connection with this drive, to take up the stretch and maintain the proper belt tension.

Ratios of over 7 to 1 are generally not used with V-belt drives. Under favorable conditions, this ratio can be exceeded somewhat but special provisions must usually be made. For the most satisfactory results, belt speeds of 4000 ft. per min. are recommended, although speeds up to 6000 ft. per min. can be used, if proper precautions are taken in proportioning the drive. At these high speeds, centrifugal force has a tendency to throw the belts away from the sheaves and belt wrapper may well be applied to counteract this tendency.

When properly proportioned for the power to be transmitted, efficiency of this type of drive need never be allowed to fall under 98 per cent. The V-belt, being elastic, will "creep" and the pulling of the ropes away from their wedged position in the grooves results in some power loss.

In addition to the requirement of proper cross section, the ropes must be pliable and flexible to prevent the generation of heat due to bending. Heat will deteriorate any rope or belt, if excessive, and materially shorten its life. For induced draft fan drives, or those of similar nature, due consideration must be given the temperature, as unsatisfactory results will be obtained should this value exceed from 125 to 150 deg. F.

Where several belts are used, operation of the drive can be continued in case one belt breaks, even if only with partial load. When belt replacements are necessary, it is usually desirable to replace all the ropes, as these should be of the same length and cross section for uniform load distribution.

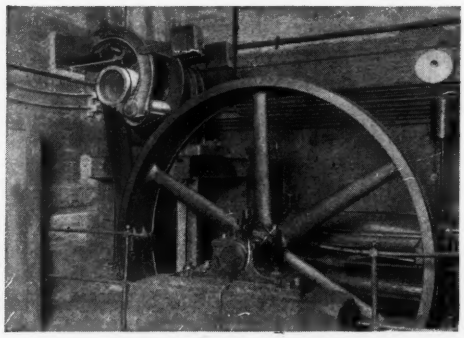


FIG. 3. 90-KW. LENIX GENERATOR DRIVE

Replacement of the ropes on drives where the shaft centers are fixed and where outboard bearings are used, usually means partial dismantling of both machines, to permit the introduction of the endless V-belts. In case of damage to either of the two sheaves, operation is, of course, held up until a new sheave is secured.

As with chain drives, V-belt drives are reversible. Vertical drives suffer somewhat but not to the same extent as chain drives.

Flat Belt Short Center Drives

This type of drive consists of two ordinary standard pulleys, a flat belt and a belt wrapping device. For efficient and satisfactory results, it is important to use a substantially designed and correctly applied belt wrapping device, as typified by the Lenix, Fig. 3. It is applicable to open drives or quarter turns but not to crossed belts.

This drive duplicates on short centers, the satisfactory results obtained with longer open flat belt drives. Center distances can be made such that only a small clearance is left between the two pulleys and the belt

wrapper pulley. Belt speeds up to 8000 ft. per min. and above are practicable and centrifugal force is in no way detrimental because any slack in the belt is automatically wrapped around the pulleys.

In action, the belt wrapping device automatically compensates for any change in the length of the belt whether due to atmospheric or load conditions. It is applied near the smaller of the two pulleys, arranged so that only sufficient room is left between the wrapper pulley and the smaller pulley for the belt to pass comfortably.

The arc of belt contact for the starting position of the unit is 225 deg. Because of this large arc of contact, belt tensions are considerably less than those needed with a corresponding open drive, as can be seen by a study of the fundamental belt formula found in any mechanical handbook, where the ratio of the tensions in the tight and slack sides depends on the product of the coefficient of friction and the arc of contact.

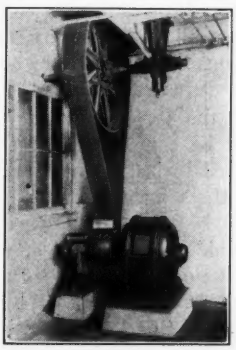


FIG. 4. BELT-WRAPPER ON VERTICAL DRIVE

The belt wrapper is provided with adjustable weights to create tension in the slack side of the belt just sufficient to transmit the required power without actual belt slippage. This adds to long belt life and reduces pressures in the bearings. Two-bearing motors or generators may be used in sizes up to 300 hp.

Efficiencies of 98 per cent are attained with this type of drive. Actual tests on an installation in service indicate an elastic creep of the belt, (present in all flexible transmission mediums), of only 0.5 to 0.75 per cent. The balance of the losses are to be divided between power required for bending the belt, air friction and the power required to revolve the belt wrapper pulley. This high efficiency is maintained regardless of the arrangement of the drive, vertical Fig. 4, or tight side on top, Fig. 5.

Provided the proper diameter of pulley is selected for the power to be transmitted, speed ratios of 1 to 20 and above are practical. This large permissible pulley ratio means high speed, efficient and inexpensive motors. Capacity of the smaller pulley determines the horsepower as well as other factors, such as belt speed, belt thickness and belt width. The following formula will enable the approximate determination of the minimum pulley diameter for a given horsepower:

$$d = (hp. \div 11) + 5$$

where d is the minimum small pulley dia. in inches. Comparing the values found from this formula with the practice of leading motor manufacturers, it will be noted that the belt wrapper type of drive permits of smaller pulley diameters. This pulley size requirement being satisfied, the pulley ratio permitted is unlimited, depending only upon space and other practical considerations.

Maintenance with this type of drive is low. Belt stretch is automatically taken care of, as the take-up obtained with the belt wrapper and the travel of the motor or generator is usually sufficient to care for the total stretch of the belt during its entire life. Pulleys are subject to no wear, as actual belt slippage is eliminated. There is no wear in the wrapper pulley, which is mounted on liberally proportioned self-alining ball bearings. The only item requiring replacement is the belt and this only after a long period. In case of a breakdown, standard pulleys and belt can be obtained from any local supply house or dealer.

Belting for these drives should be endless and extra flexible but any high grade of flexible leather, rubber or fabric belting, if made endless, will give satisfactory results. Leather belts have the advantage of being easily made endless in the field and of being able to withstand considerable momentary overloads. Up to this time, no satisfactory or convenient method has been devised whereby rubber belts can be made endless on the job and it is usually advisable to have this type of belt made endless at the factory. Rubber belts have the advantage of being perfectly uniform in cross section and pliability, which is desirable.

Modern short center, flat belt drives and V-belt drives inherently possess the element of elasticity and with the modern belt wrapper drive, the units are protected in case of a dangerous overload by the belt slipping until the danger point is passed.

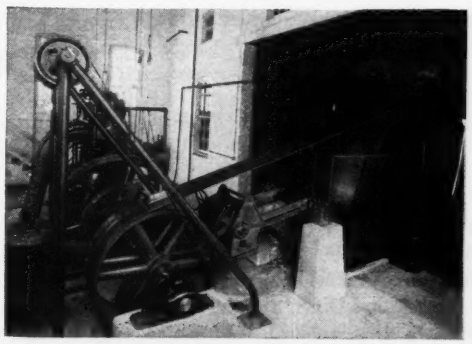


FIG. 5. 180-HP. MAIN DRIVE WITH TIGHT BELT ON TOP, BELT WRAPPER BELOW

For high peripheral speeds, in excess of 5000 ft. per min., it is advisable to investigate the mechanical strength of the pulleys. Use of cast-iron pulleys is unusual for such speeds. Cast-steel pulleys, steel rimmed pulleys with cast-iron spokes or pressed steel pulleys with turned rims are usually resorted to. It is important that the face be turned true when using these speeds, as inaccurate rims will lead to wabbling of the pulleys and cause an unstable condition of the belt. Proper crowning of the pulleys is a matter of importance also, too much crown causing considerably shortened belt life and too small a crown being insufficient to control the position of the belt on the pulleys.

Belt thickness to give the most satisfactory results also bears a definite relation to the smaller pulley diameter. This can be found approximately by use of the following formula:

$$t = (a \div 110) + 0.21$$

where t = belt thickness, in.; d = small pulley dia. in.

Special Flat Belt Drives

Under this heading may be first mentioned a drive employing a special combination belt as the transmission medium. The belt consists of two or more plies, an inner ply of longitudinal chrome strips which supply the friction contact and other plies or backing of leather or balata belting, the chrome strips being riveted to the backing by means of hollow brass rivets.

This drive is simple in design and compact in arrangement. Short centers can be used, although there are limits depending upon the arc of pulley contact and the nature of the load. Horizontal or inclined drives with the taut side of the belt on the bottom are preferred. Vertical drives can be used, if proper precautions are taken as to the tightening of the belt but, in general, they should be avoided for the same reason as in the cases of the first two transmission mediums discussed. A belt speed of 3000 ft. per min. is considered ideal. Although this can be exceeded considerably, the effect of centrifugal force at high belt speeds will influence the operation of such drives to a certain extent. Arcs of contact with this type of belt should never be under 135 deg. Belts should preferably be made endless at the factory although metallic fastening methods may be employed.

It is important that tallow dressing be applied at intervals to the chrome strips to prevent the belt from slipping; also, that the correct belt tension be maintained, as otherwise the belt may slip and burn. When overloaded, there is, with this type of belt, a tendency on the part of the rivets to pull out, if the chrome strips and the backing stretch unequally, a condition which can be avoided by liberal proportioning of the belt for the drive.

Another type of drive offered on the market and well suited for comparatively small horsepowers, uses two standard pulleys and a standard leather, rubber, fabric or balata belt. The belt tension is created by the weight of the motor supported on a hinged, spring-balanced support.

In conclusion, in making cost comparisons between the various types of drives, the item of first cost is not the only one to be given careful consideration. Satisfactory service with minimum shutdowns is an item that means money, particularly with production machinery. Low maintenance deserves proper consideration. The efficiency of nearly all modern short center drives will be found to be approximately 98 per cent, which should of course also be duly considered.

In comparing the costs, it is the total cost of the drive that should be considered; that is, if a drive is estimated or desired to last a given period of years, the length of life of the transmission mediums of the various drives should be taken into consideration and the cost of the probable replacements of such transmission mediums in that period of time added to the first cost of the drive proper before the comparisons are made. Admittedly, it is difficult to estimate the life of a transmission medium but the experience of the various manufacturers with thousands of such drives will at least give the user some idea as to what life may be expected so that such a cost comparison can be made.

Group Drives

Advantages in Economy, Effect on Peak Load and Power Factor. Belts Should Have Ample Capacity. By J. R. Hopkins*

IN A WELL PLANNED group drive, total power losses average 7 to 10 per cent; even in one poorly planned, losses are rarely over 30 per cent, which should be compared with underloaded motor loss of individual drive. Most machines require about double the power to start up that they need for running. With group drive, all machines do not start at the same time and, during production, the load is seldom maximum for all machines at the same time. Group-drive motors can, therefore, be purchased for the average load.

Economy in operation and maintenance and lower installation costs are gained by grouping many dissimilar machines as well as in grouping machines all of one type. Both can be made to work perfectly, with high power factor and production efficiency.

For a group drive, the ideal is from 60 to 20 machines requiring a motor of not more than 50 hp. as that is the largest size motor that can be handled quickly. For machines that operate steadily all the year around at about the same load, the size of the group is a matter of convenience. One shaft the length of the room is entirely permissible. In a group of many dissimilar machines, there are advantages in making the group as large as possible. Two line shafts the length of the room are not too many, driving one line shaft from the other. It is not good practice, however, to have more than two room-length line shafts on any group drive, as each cross belt from one line shaft to another reduces the efficiency and the power factor.

Advantages of Group Drive

Group drives may be installed at low initial cost and to improve the over-all power factor of the plant. A smaller motor may be used on a group drive than the aggregate of the motors on unit drives.

It is possible to use hangers and fittings on hand, also hangers and pulleys may be used over again, if the plant or department is changed. Group drive increases the flexibility since a new machine may be installed in any location.

Comparison of group and individual drive can usually be reduced to figures and the decision arrived at by

*Chicago Belting Co.

comparing motor sizes and loads with installing, operating and maintenance costs.

Speed of Motors

In a large plant, having thousands of motors, motor speeds must be standardized and these standardized speeds are never very high.

If the motors are kept within the standard speed range adopted by the plant for maintenance and replacement economy, the number of extra motors kept on hand for quick replacement can be reduced to the minimum but, even when this number has been made as small as is possible, it will still include a great number of motors and parts. With standardized motors, repair work and changing of motors are also standardized and kept within reason.

In fact, all good maintenance men know that, in a big plant, unless motors are standardized there is endless trouble, delay and added expense, as nothing fits, nothing seems to get itself done quickly and everything seems special.

What is not so well realized is that, if motor standardization and speed standardization are important in a large plant, they are even more important for smaller plants because the smaller plant has less money to appropriate for maintenance and repairs. The big plant with its large number of spare motors and facilities for changing motors when one goes bad can do many things that the smaller plant cannot do.

Thus the average plant finds the high-speed motor either unavailable or requiring two off standard motors, to have one in reserve, if the machinery is to be kept in continuous production.

This works back to the consideration that motor efficiency and motor costs must be considered for actual use in the average plant and not as they might operate under some ideal condition were each machine the only machine in the plant.

Savings Through "Overbelting"

One large user of leather belting has had remarkable results through eliminating all light weight belts. In fact, all his belts weigh 16 oz. in the single and never lower than 28 oz. in the double. This eliminates lightweight singles and doubles, so that on drives where the work to be done indicates that a light weight belt would do the work, they are apparently overbelted, for they have more belt than they actually need. Yet annual bills for belting have been materially reduced as putting on heavier weights, has increased the length of belt life to a point where it more than compensates for the greater cost of the heavier belts.

In theory, it is easy to reason that a belt should be as thin as possible. Light-weight belts are thinner and are accordingly more pliable, a good point in their favor. In practice, it works out that the heavier weights take the load more gracefully, distribute the load more evenly and stand up much better.

Belts Purchased on Price Suffer in Overload Capacity

In belt transmission, you always have to allow for the unexpected overloads. On many machines, peak loads appear at more or less regular intervals; on all machines, the starting loads are higher than the running loads; all of these overloads have to be provided for. A good leather belt has pretty close to 100 per cent overload capacity; that is, for brief periods the belt will take 100 per cent overload and stand up under it. It may slip and squeal but it will stand up.

The point is that on many machines you never know when the overload may develop and rarely just how much this overload will be. So, if you start in to use as little belt as possible, you are likely to draw the belt ratings too fine and have a belt that, in theory, should stand up but, in practice, either does not or wears out too quickly.

All engineers know that, when price is the deciding factor, it is overload capacity that suffers most. This is true of most materials. It is especially true of belting. Driven to furnish a belt to meet a price, more often than not the finished belt will apparently be what was ordered but will lack the all-important overload capacity that it would have had the buyer not pressed too hard for price.

It is customary for the purchasing department to be free in deciding where to buy and what to buy in leather belting. The plant, however, should always but doesn't always decide weights and widths. It is easy to specify a little more weight, or a little greater width if one chooses. Of course, on width one is limited by the width of the pulley but many belts can be made a little wider on existing pulleys.

The plant should also dictate tannage. Three tannages of leather are used for belting. Oak is used on 85 per cent of all leather belt drives, combination tannage on 10 per cent and chrome on about 5 per cent. Most of the leading leather belting manufacturers make belts of all three types. All maintenance men should understand the limitations and advantages of each type.

It should be remembered that the manufacture of leather belts has advanced considerably in recent years; belts are better made for their work, are engineered better. There is a leather belt that will work successfully on any drive, good, bad or indifferent. If you have trouble, if you have drives that displease you, somewhere you can find a better belt that will eliminate your trouble and that will be satisfactory.

Wire Rope Replacement

Cost of rope replacement includes not only the price of new rope but time of men for stringing, loss of output of machinery, unless the work can be done nights or holidays, and often the wages of operatives, idle during the shutdown.

Obviously, the shorter the shutdown, the less the expense, hence rope that is free from crankiness, lies straight rather than kinky and can be cut without seizing the ends is an advantage.

One item sometimes overlooked is that an old rope, which has worn to undersize, tends to wear undersize grooves in the sheaves, unless the grooves have surfaces of manganese steel. One of the worst abuses of a new rope is pinching in undersized grooves, hence, when making a replacement, sheaves should be inspected, grooves tested and turned to correct size, defects in grooves or rims repaired or sheaves replaced, as may be needed. This expense is properly a part of rope replacement.

Evidently, it is an object to have replacements as

few and far between as possible. This means the use of rope and sheaves that will have the longest life and generally, "the best is the cheapest," tests and records being the guide in each case as to what is "best."

Replacement on nights or holidays does away with production and idle-time losses. This must be planned for so that rope will be run as nearly as possible to the end of its life. Regular inspection is necessary so that replacement may be made before actual failure occurs, yet not sacrifice too much of the life of the rope. If internal friction and chafing are low, the wear will be greatest on exposed surfaces and condition can be judged quite accurately. Factors in reducing internal friction are good lubrication, avoidance of excessive loads, use of high-grade steel which will have good spring tension when bending into or straightening from the sheaves.

Replacement before failure has, too, the advantage of avoiding accident with their attendant possibilities of injury to workers, damage claims, hospital expense and loss of morale. For safety's sake, it is better to replace a little too soon than to wait too long.

Steam to Make Fine Feathers

HEAT WITHOUT WETNESS BUT NOT TOO DRY. THE ENGINEER SOLVED A PRODUCTION PROBLEM. BY FRED S. RUTLEDGE

CLEANING AND STERILIZING feathers was the work of two machines in a plant. As originally built, they were like Fig. 1 with inside measurements 8 ft. long by 4 ft. wide by 8 ft. high. In the bottom is

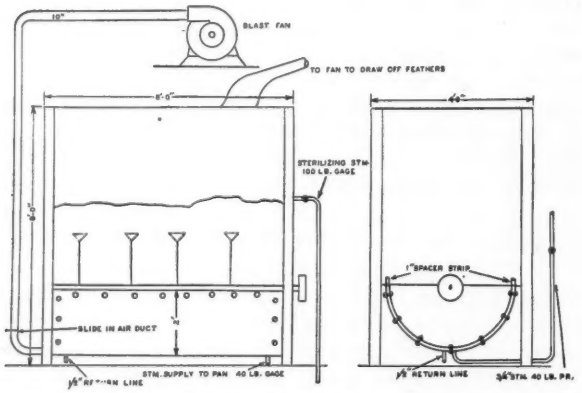

BLAST FAN
TO FAN TO DRAW OFF FEATHERS
STERILIZING STM. 100 LB. GAGE
SPACER STRIP
SLIDE IN AIR DUCT
STM. SUPPLY TO PAN 40 LB. GAGE
RETURN LINE

FIG. 1. FEATHER STERILIZER AS FIRST INSTALLED

a drying pan make of two ⅜-in. boiler plates, spaced 1 in. apart and riveted through both plates and the spacer strips as shown. The flat surface is properly staybolted to stand 40 lb. operating pressure. The steam supply came in by a ¾-in. pipe at one end at the bottom and the ½-in. return went out at the other end, the pan being set ¾ in. low on the return end for drainage. Lengthwise through the machine runs a shaft $1\frac{15}{16}$ in. in the bearings and 4 in. inside the machine, having 1-in. diam. arms 40 in. long with small paddles on the ends of the arms to stir up the feathers.

TOO MUCH MOISTURE IN STEAM

After the feathers had been put in the machine and stirred up a sufficient length of time to dry, they were sterilized by turning live steam, at 100 lb. pressure into the machine, for a period of from 3 to 7 min. The blast fan was then started and cold air blown into the machine to cool the feathers.

Frequently, trouble was encountered from water getting into the feathers with the sterilizing steam which cut down the temperature and increased the time required to dry the feathers. Also blowing in cold air cooled them down unduly and, under certain atmospheric conditions, seemed to increase their dampness.

All kinds of separators and trap combinations were tried on the sterilizing line to eliminate the moisture but it was like the poor, "always with us."

STEAM DRYING COIL

Figure 2 shows how we first doctored the sterilizing steam line. Fittings were used and a double-pipe coil, on the same principle as a double-pipe ammonia coil, was made up and placed ahead of the inlet to the machine. The outside pipe was 2-in. and the inside pipes were 1¼-in. Steam from the 40-lb. line was connected into the 1¼-in. pipes and at 100 lb. into the 2-in. Fig. 3 shows one of the return bend type of fittings and one of those for connecting the supply and return lines to the coil.

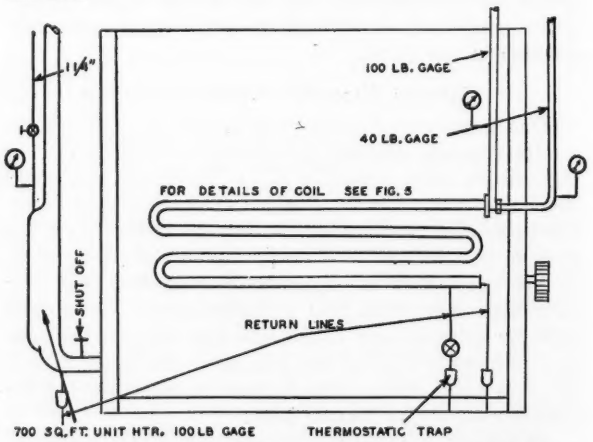


FIG. 2. A DOUBLE-PIPE COIL HELPED TO DRY OUT STERILIZING STEAM

Figure 4 shows the change made in introducing the sterilizing steam. Instead of shooting it into the end of the machine, eight 1¼-in. pipes were welded into the 2-in. pipe. These were put through the wall of the machine just above the pan, with elbows on the end pointing down. The idea of the double pipe jacket was to keep the steam as hot as possible while expanding to atmospheric pressure. As shown in Fig. 2, steamfitters made one mistake and connected up a thermostatic trap to the 2-in. part of the coil. This let air suck back through the 1¼-in. pipes and was soon taken off.

This arrangement worked a little better but the machine was getting cooled off too much in getting the feathers out. Altogether it was averaging from 60 to 75 min. per batch.

Next 3 ft. was taken off the top of the machine which helped a little. Then a Modine unit heater of 700 sq. ft. rating was place in the air spout, as in Fig. 2 so that all the air blown into the machine passed through it. This helped a little more. Still the required amount of material could not be passed through the machine. The amount had increased from 600 lb. to 1000 lb. of feathers

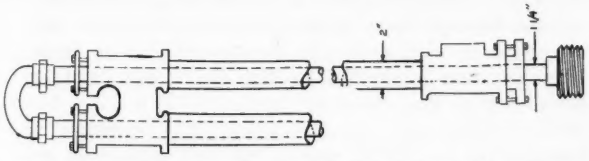


FIG. 3. RETURN BENDS AND CONNECTIONS FOR STEAM WERE MADE LIKE THIS

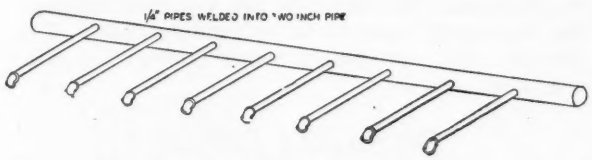


FIG. 4. STEAM WAS FED IN THROUGH EIGHT 1¼-IN. PIPES

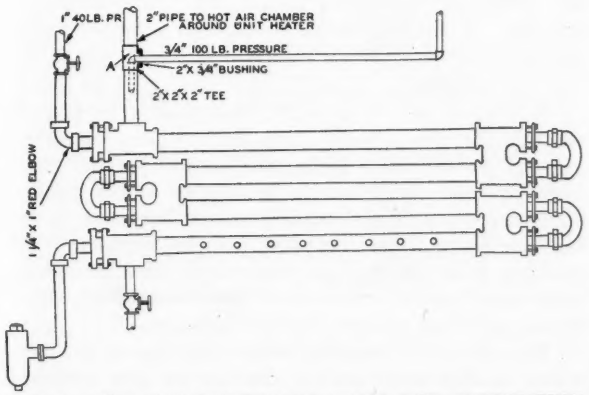


FIG. 5. HOT AIR SUCKED IN WITH THE STERILIZING STEAM KEPT THE FEATHERS DRY

an hour but a machine of this size should handle 1800 lb. an hour.

Hot Air Absorbed the Moisture

Some more reconstruction and ideas were carried out and Fig. 5 is the coil as now used. As shown at A, the 100-lb. steam line was brought into a tee, an ell screwed on with a short piece of pipe inside the 2-in. pointing in the direction of the steam flow. A 2-in. pipe was run from the tee back to the chamber of the heater so that, when the steam was turned on for sterilizing, the injector action drew in hot air to flow along with the steam. Hot, dry air has quite an affinity for moisture and this idea seemed to be the last requirement, as there has been no trouble with moisture since. The trick was to keep the temperature up while expanding steam from 100 lb. down to atmospheric pressure or nearly so.

Most of the trouble was then with the operator, who was bound to work by the clock. So a recording thermometer was installed and the operator shown how to work according to temperature instead of time. The original operator was "wise" so he broke the recorder, as he had to handle too many feathers. He quit by request and a new man was put on. Now 1800 lb. hourly is the schedule instead of 600 lb.

Static and Steam

In the process of handling feathers, they are separated into different grades by gravity, being fed into one end of a machine that has an agitator similar to that in the sterilizer to keep the feathers stirred up. As shown in Fig. 6 the feathers are fed in at feed box and any sand, stones or other heavy material is dropped through the screen to the compartment below where it is removed through a door in the side. On the opposite end is a suction fan to draw feathers through the machine, the feathers being separated by gravity, the heaviest feathers falling in compartment No. 1 and so on until only down falls in the last compartment. Numerous windows in the sides of this machine permit observing what is taking place inside. Compartments are connected with air spouts, at the bottom so that stock can

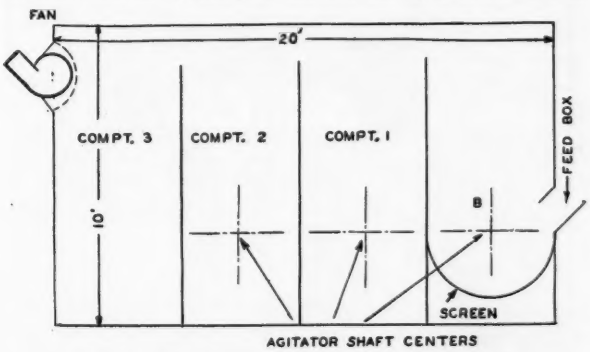


FIG. 6. FEATHER GRADER AND CLEANER

be removed by a fan, a system of spouting and dampers and deposited in storage bins.

Rotation of the agitator arms through the feathers inside the machine would, when feathers were perfectly dry, create static electricity causing the feathers to hang on the walls and partitions inside the machine thus decreasing the capacity and mixing the grades. First, sprinkling the feathers with water when put into the feed box was tried but, if they were wet too much, it caused trouble. So a ½-in. steam line was introduced at B and a regular whistle valve put on. We found that a very small amount of steam, admitted as soon as the feathers started to hang to the glass of the windows, would clear things up, keep the grades more uniform, increase the proportion of down, which is the highest-priced grade, and increase the total amount handled by 50 per cent.

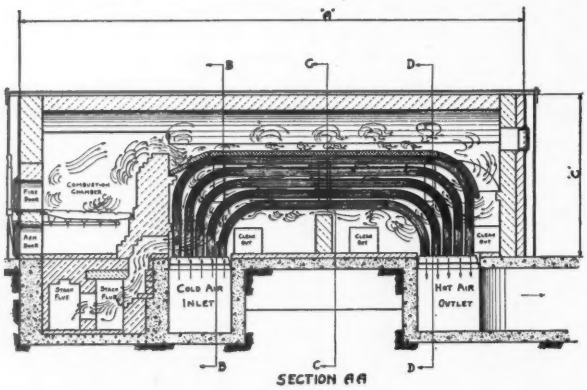
Iowa Railway and Light Corp. will install a 2400-hp. generating plant at Nevada, Iowa, this summer, C. I. Merrick, Nevada, manager, has announced. The unit will consist of two 880-hp. engines and a third of 600-hp. on a daily schedule to supplement the steam plants during peak load periods. A new building, 58 by 75 feet, will be erected to house the plant, the total investment being estimated at $250,000.

Centralized Heating Without Steam

DEVELOPMENT by the Lee Air Heater Co., Youngstown, Ohio, of a new system with fan circulation of warm air through ducts, has made possible the heating of large industrial buildings by warm air. The furnaces are of a new design, modified from the steel plant recuperator and constructed to withstand heavy firing. Forced circulation of the air through the tubes of the furnace, provides efficient cooling and prevents burning of the metal at high loads. Uniform distribution of the warm air to every part of the building is secured by a system of underground or overhead ducts.

Air fan and, on the same shaft, a smaller fan to provide induced draft for the furnace, are driven by a variable speed motor.

Distribution of warm air at working level and the removal of cold air from the floor, make it possible to maintain an even temperature throughout the building,



without carrying excessive temperatures up under the roof in order to warm the floor. Time needed to heat the building is reduced because distribution of heat starts as soon as the fire is lighted and no banked fire is needed to keep up the steam pressure. In mild weather, the fire may be allowed to go out in the afternoon, the building being made comfortable the next morning by the use of a little kindling and a few shovels of coal.

The system is simple to operate. No maintenance can be required beyond the occasional oiling of the fan bearings and such infrequent repairs as are needed by the grate and furnace. The heater is usually placed in a lean-to at the side of the building, or any other available location, no basement being required as no condensate is returned. Fans and ducts are available for ventilation in the summer, and air conditioning equipment can easily be added.

Pipe Joint for Long Spans

CROSSING the Hudson River where the river is somewhat over a mile in width, a pipe line has recently been completed of extra heavy 8-in. pipe, designed for an ultimate pressure of 100 lb. per sq. in. and at present carrying a pressure of 45 lb. All joints were welded by the oxy-acetylene process on a barge and the pipe lowered away into the river-bed as the barge was moved forward. The joint used, as shown in the drawing, consists of a standard butt weld, reinforced by a short piece of 9-in. standard pipe which fits over the butt weld and is welded to the pipe at both ends with fillet welds. This stiffens the pipe at the joint against bending stresses., also provides an extra factor of safety since two welds would have to prove defective before leakage could occur at any joint.

Each of the 9-in. pipe sleeves was provided with a hole threaded for a ⅛-in. pipe nipple. Because an air compressor capable of providing the high test pressure required was not available, compressed nitrogen at 1,000 lb. was used for testing, in cylinders similar to oxygen cylinders. Oxygen must never be used for pressure testing, because under pressure it will react with explosive violence if it comes in contact with oil or grease. Nitrogen was connected to the $\frac{5}{32}$-in. annular space between pipe and sleeve by means of ⅛-in. pipe, fitted with a valve and pressure gage. The pressure was brought up to 350 lb. per sq. in. and soap suds were painted on the sleeve welds. If the pressure dropped and no leaks in the sleeve weld could be detected, it would indicate that the center butt weld was faulty and the pipe would have to be cut and rewelded. This, however, did not happen once during the entire operation.

Oil Soaked Belting

ALTHOUGH OIL damages some belts but little an excessive amount of oil does cause slipping. As soon as slip occurs there is power loss, directly proportional to the slip. If the slip amounts to 2 per cent the power loss is 2 per cent; if the slip is 5 per cent, the power loss is 5 per cent.

Continued use of a leather belt soaked in mineral oil will develop cracks from inside fiber abrasion. Natural animal oil in high-grade leather protects these fibers against sawing one on the other. Harsh mineral oil removes this film of natural animal lubricant, allowing the fibers to contact and develop abrasion. Degreasing will remove the mineral oil and redressing with animal oil will replace the film on each fiber, which means pliability without internal damage.

Excessive slip may also cause burning of the belt, which is often more serious than power loss, cracking, and abrasion combined. It can be very expensive.

Two ways are possible to tackle this oil soaked belting problem: First. Improve your oil conditions, if possible, so that there will be no leakage or splattering onto the belt. By so doing, it will be unnecessary to give the belt a periodic cleaning.

Second. Use a belt that is as immune as possible to harm by oil; then clean that belt periodically.

Numerous cleaning agents are used for washing leather belts such as gasoline, naphtha, kerosene, benzol, carbon tetrachloride, aqua ammonia, alcohol, soda and water.

In general, these rules may be followed: Immerse the loosely wound coil, on edge, in the liquid and allow to soak over night. Then stand on the other edge for 10 hr. If the belt is dirty in addition to being oil soaked, the dirt usually loosens and settles to the bottom. Dirt that does not loosen and settle can be removed by brushing or scraping. To hasten drying the belt may be run through a wringer. S. W. F.

Eliminating Engine Cylinder Lubrication

DETAILS OF METHOD OF BREAKING IN STEAM ENGINES TO OPERATE WITHOUT CYLINDER LUBRICATION. OIL SHOULD NOT BE USED

STEAM ENGINES in marine service are usually operated without cylinder lubrication, depending entirely upon the glaze of the cylinder liner and water of condensation to prevent friction and undue wear. When lubrication is provided, a pure uncompounded mineral oil is preferred, the use of tallow, vegetable or animal oils of all kinds being frowned upon both because

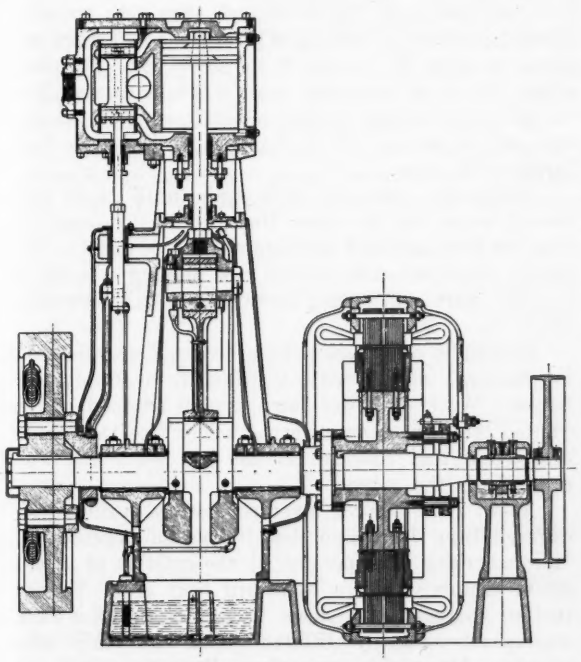


FIG. 1. SECTIONAL VIEW OF A STEAM ENGINE GENERATOR SET

of the difficulty of separating them from the exhaust steam and the danger of corrosion unless a high grade, acid free product is obtained.

In stationary practice, cylinder lubrication of some kind is usually provided, a compounded oil of some type being the most common. For ordinary service, an oil compounded 5 to 10 per cent usually with lard oil, de gras or tallow is used, as a general rule, the compounding increasing with the steam pressure and temperature. Oil and grease extractors are used to separate the oil from the exhaust steam and in some cases chemicals are used to remove the last traces from the condensate.

For some services, however, especially where the exhaust steam is used for certain processes or in closed feedwater heaters, it is sometimes considered advisable to operate a stationary engine without cylinder lubrication.

For the best performance without lubrication, the engine should be built for that purpose or rather the cylinder piston and valve should be dusted with finely powdered graphite as they are assembled in the engine. Furthermore, no oil of any kind should be allowed to get on these parts as oil seems to prevent proper glazing of the surface.

It is sometimes said that previous operation with lubrication brings about a change in the surface of the cylinder which renders subsequent operation without lubrication impossible. This is not entirely true, as there are engines in service running without cylinder lubrication which previously have been operated with lubrication. They are giving good service but experience shows that the cylinder walls take a better glaze in a shorter period of time if no oil has been used.

After the cylinder surface has been properly glazed, water due to condensation acts as a lubricant. It is usual to operate engines in this way only with saturated steam although low superheat can sometimes be used.

As mentioned above, the engine should be built especially for operation without lubrication so that the initial treatment with graphite can be given during

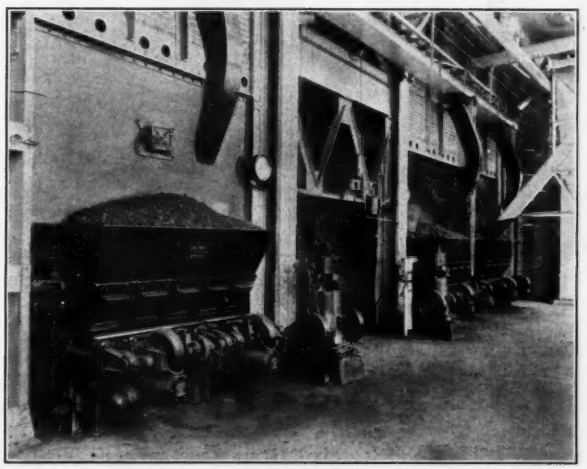


FIG. 2. FLEXIBILITY GIVES THE ENGINE ADVANTAGES FOR STOKER DRIVES

assembly. The following method is used by the Engberg Division of the Troy Engine & Machine Co. The engines are run in at the factory and the engineer or operator is given instructions to taper off the treatment gradually until, at the end of one to three months, no further lubrication is required.

After the engines are assembled and placed on the test block, they are liberally treated with a mixture of heated beeswax and finely powdered graphite. Fine graphite is preferable, as the flake type has a tendency to gum up the piston rings. The beeswax serves only as a binder so that as much graphite should be mixed in as the wax will hold.

After thoroughly mixing, the material can be cut into pieces and introduced into the steam line by means

of a large compression grease cup or certain types of cylinder lubricators. In order to prevent all the mixture being pulled into the cylinder at one time, a valve should be placed in the line between the steam line and grease cup.

After the grease cup and mixture have warmed up, the engine is turned over slowly and some of the graphite introduced by opening the valve four or five seconds. This permits sufficient wax to get into the steam chest and cylinder to last a half hour or so. The engine is run this way for about a day, the beeswax and graphite mixture being fed in every half-hour.

During the first half of the next day, the engine can be speeded up to half speed, the graphite feed continuing as before. After this treatment, the engine can be operated the second half of the day at full speed but without load. After the second day's operation, the cylinder head should be removed and the glaze on the walls inspected. Parts that do not seem to be properly

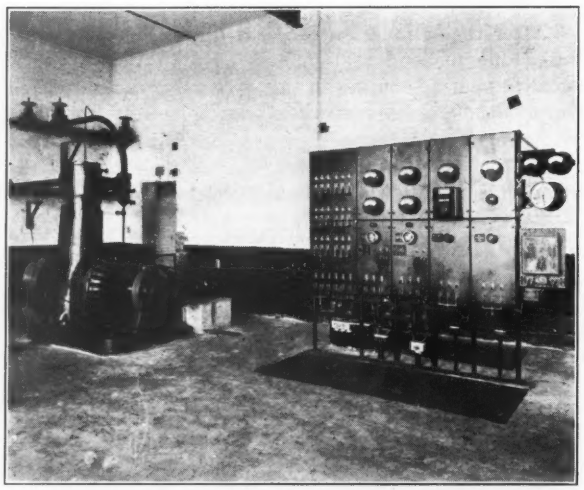


FIG. 3. SMALL PLANTS FIND GENERATING SETS OF THIS KIND CONVENIENT

glazed should be rubbed well with the graphite mixture.

During the next two days, the engine can be operated full load, full speed and the graphite feed can be cut down to once each hour. After the engine is in service, it is difficult to give definite instructions because of the difference in operation and service.

In general, however, the mixture should be fed every hour for the first week, every two hours for the second week, twice a day for the third week and once a day for the fourth week. At the end of this period, some engines will be ready to operate without any further cylinder lubrication but others will require a longer period. Larger engines require longer periods of treatment than small engines. The operator can tell by the sound of the machine whether more graphite is needed and can taper the treatment down during the last part of the period to meet local conditions.

APRIL SHIPMENTS of domestic pumps and water systems as reported to the Department of Commerce by 39 manufacturers, totaled 10,104 water systems, 38,382 pumps and 13,267 cylinders shipped separately.

Early History of Power

APPARENTLY the first demand for power was in connection with the pumping of water, the compressing of air for forges and the turning of mills for grinding grain. Treadmills were in early use and appear in ancient drawings of before 200 B. C.

Steam, wind and water power were all apparently tried about the same time. The steam turbine of Hero which dates around 100 B. C., is well known. About the same time, he also built a windmill used to compress air for an organ. The windmill had four wooden pegs set at 90 deg. around a shaft and these, by means of a lever, raised a piston four times each revolution. The piston on falling compressed air in the cylinder.

By 15 B. C., apparently both the water wheel and treadmill had been well developed; they both appear as illustrations in the writing of Vitruvius and were mentioned at least 50 yr. earlier by Antipater. The water wheel played an important part in the industrial life of the following centuries and, as early as 1086 A. D., a tide mill is mentioned at the port of Dover as interfering with ships.

Windmills were not used again until their rediscovery about 600 yr. after Hero, while the steam turbine lay dormant until the time of Parsons and De Laval late in the nineteenth century, not playing a really important part until the beginning of the twentieth century.

Hydraulic compressors were invented sometime during the early middle century primarily to supply air to forges. Water running down a pipe trapped air and carried it down to an inverted bell where the air separated out and collected at the top while the water escaped out the bottom.

About 1630, Branca invented a steam turbine which differed from Hero's in that it was an impulse type. Hero's turbine was operated by the reaction of a jet of steam escaping from a backward bent arm. Branca's turbine consisted of a steam jet impinging on a paddle wheel, not radically different from the early water wheels. About the same time, Branca experimented with a hot air turbine.

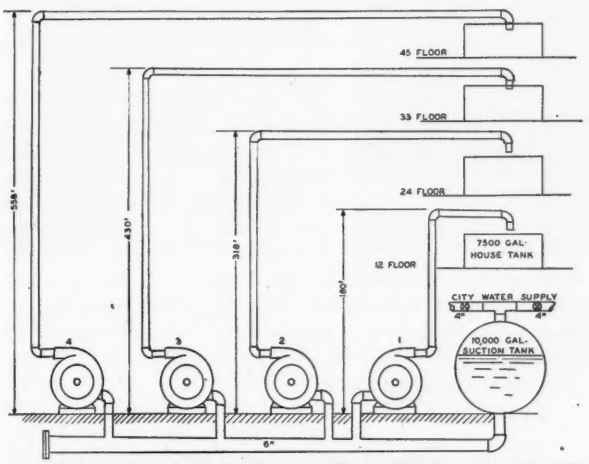
Steam engines can be dated from the inventions of Savery in 1698 and Newcomen in 1705. Both were inefficient but, until the improvements by Watt, were actually used in a small way for pumping water. A high-pressure engine was described by Leopold in 1725 and a steam engine was applied to a vehicle in 1769 by Cugot in an attempt to develop a steam propelled gun carriage.

Brayton, in 1873, is generally credited with the invention of the first practical internal combustion engine although Huyghens, in 1680, actually built an engine using gun powder. Barber, Lenoir, Beau de Rochas, Otto, Clark, Ackroyd and others, all played an important part in engine development but it was not until the invention of Diesel, in 1892, that the development of large sizes began. Diesel's first commercial engine was built in 1897.

The electric motor is said to have been discovered in 1873 at the Vienna Exposition where it was found that either one of two Gramme dynamos could set the other in motion. Thus it is seen that our whole modern power development covering but a brief 30 or 40 yr. is the culmination of over 2000 yr. work and study.

Pumps Work Best When Well Fed

TOTAL ENERGY required in pumping includes not only that needed to push the fluid to another location but that necessary to draw the fluid into the pump also. If the amount of work required to feed the pump is increased, the energy the pump has available for pushing the liquid to its destination is correspondingly reduced.



ARRANGEMENT OF SUPPLY LINES, PUMPS AND HOUSE TANKS WHICH ARE LOCATED ON DIFFERENT FLOORS

Lack of conception of this principle led to trouble with our pumping system.

Water supply to our 44-story office building enters the building through two 4-in. pipes at 50 lb. press., as shown in sketch, discharging into a 10,000-gal. suction tank. Four motor-driven centrifugal pumps rated at 100 g.p.m. at 1750 r.p.m. raise the water to the four house tanks located on the different floors as shown. Number 1 is a single-stage pump driven by a 7½-hp. motor, No. 2 a two-stage pump driven by a 15-hp. motor, No. 3 a three-stage pump driven by a 25-hp. motor and No. 4 a four-stage pump driven by a 30-hp. motor. These are automatically operated through float switches.

When two or more pumps ran at the same time, the water end of one of the pumps would run hot. Internal inspection disclosed no imperfection but the valve on one of the 4-in. supply lines had been closed by one of the attendants with a view of conserving the water supply. The result was that when more than one pump operated, the pressure on the intake dropped from 50 to 20 lb. and the pumps were not able to deliver the water to the tanks but simply churned the water in the pump casing. When both of the 4-in. valves on the supply lines were opened, the pumps gave no further trouble.

New York City. THOMAS SHEEHAN.

Purchasing Coal for Isolated Steam Plants

I HAVE HAD your November 1 issue in front of me for some time and the article by Mr. Swoboda on page 1156 has proved to be my Waterloo. I have read it over a dozen times and have tried to forget it but I can't do it.

Offhand I think the old engineer and the purchasing agent showed good judgment in selecting the No. 1 coal.

On looking at Table I and the prices in Table IV, it is evident that the purchasing agent did not buy solely on a price basis either on tonnage or B.t.u.

	I	II	III	IV	V
B.t.u. per pound.....	13,201	14,091	14,569	13,017	13,729
Dollars per ton.....	3.10	3.10	4.25	3.50	3.15
Cents per million B.t.u...	11.72	11.00	14.60	13.43	11.48

On a B.t.u. basis, No. I is third from the lowest price, showing that he did not overlook B.t.u. value and was considerably influenced by the engineer.

Mr. Swoboda tabulates the analysis of all the coal available in the district and then writes specifications which exclude three of them for physical reasons, I and IV because of low B.t.u., I, IV and V because of high ash. One of the remaining two is excluded because of price, leaving only one, that is No. II, which he admits is of a questionable source and probably not dependable.

He spent considerable time and money making tests reported in Table II and figuring them out on a uniform basis as reported in Table III, to get the same results less accurately than he could have done from the laboratory analysis in 5 min. without any tests at all.

Just to make this clear, I will analyze the first one, No. I. At the test condition of 193-deg. water and steam at 189 lb. g., each pound of water evaporated has 1037.4 B.t.u., which, at a test evaporation of 9.3 lb. of coal per pound of water, is an efficiency of 73 per cent as reported for 13,201 coal. Now, on the adjustments of Table II, if the feedwater had been 210 instead of 193 deg., there would have been 210 — 193 or 17 more B.t.u. per lb. available for steam making. The pressure change from 189 to 185 is a heat change of only about 0.4 B.t.u., therefore, negligible. If the efficiency had been 75 instead of 73, there would have

been 13,201 × 75 or 9900 B.t.u. absorbed instead of 13,201 × 73 or 9650 B.t.u. or 9900 — 9650 = 250 more B.t.u. absorbed from the flue gases.

Each pound of coal evaporates 10 lb. of water, so that with a 17 deg. higher feedwater temperature, there would be 10 × 17, or 170 more B.t.u. available for making steam from each pound of coal burned. There would also be the 250 extra B.t.u. from the higher efficiency or a total of 420 more B.t.u. to make steam and this amount of heat would have made 0.4 lb. of steam for each pound of coal fired.

From the analysis figure of 13,201 B.t.u. per pound, an assumed efficiency of 75 or any reasonable value based on past performance could just as well have been taken, the heat content of the steam at the pressure required, calculated and the results of Table III figured out in two operations for each coal instead of involving all the test expense, trouble and calculations indicated in Table III where about two dozen calculations enter in, hence give greater chance for error. Coals III and IV are ruled out because of price, regardless of their performance, so why spend time testing them?

Coal II, if reported unreliable, should have been investigated before testing as there is nothing more demoralizing to a boiler room personnel than to be changing coal or getting coal that is not up to specification. Regardless of contracts and samples, it is practically impossible for an engineer or a fireman to get the management to do anything about inferior coal; the agents usually manage to convince the owners that the firemen are at fault. A coal company that cannot be depended upon to furnish a representative shipment for trial should not be considered seriously.

Unless conditions in that small plant are different from those in the usual plant, there is no reason to figure the cost of handling refuse as so much a ton, unless the ashman is paid by piecework. The man has to be around anyway and an extra wheelbarrow or so a day is not going to make much difference to him. Again, charging for this at the rate of 35 cents per ton of coal handled, is high. Provided none of the refuse was lost up the stack and that it was all collected, a ton of coal with 15 per cent ash and 30 per cent combustible matter in the refuse would amount to about 400 lb. of refuse. At the rate given in Table IV, 35 cents per ton of coal would be $1.75 per ton of refuse which is excessive.

To consider every item of cost, he should not have overlooked the penalty clause in the specifications. This would have made a considerable difference in the cost of some of the coals. For instance No. 1 would have a penalty of 5 cents for low B.t.u. and 7 cents for high ash making a total of 12 cents and reducing the price of this coal to 3.10 — 0.12 or $2.98 per ton. For No. IV the penalty for low B.t.u. would have been 2 cents for high ash 12 cents and for high sulphur 10 cents making a total of 24 cents and reducing the price per ton from 3.50 to $3.26. For No. V the only penalty would have been 2 cents per ton for high ash.

Summarizing the matter we find that five coals were available in the district. Two of these coals, III and IV, must be ruled out at the start because of high cost; one, II, should not be considered because of questionable mine conditions and because it had a high volatile content likely to cause smoke and because it had a low ash content hardly enough to keep the grates cool so that it would mean high maintenance and one coal No. V showed up poor on test, probably the engineer had tried it before and found it unsuited to their conditions or furnace.

With four of the five coals out of the way, I do not see that the engineer or purchasing agent could do anything else but buy the No. 1 coal which they were using. The article infers that the purchasing agent and engineer used poor judgment in selecting the coal, whereas the facts prove that they selected the only possible coal that it was practicable to use and furthermore that they selected it without a lot of useless tests and costly changes.

Springfield, O. F. PAUL.

Indicator Is Valuable Means of Checking Valve Setting

ALTHOUGH the article on Corliss Valve Setting Without Indicator, published on page 718 of the June 15 issue, was read with considerable interest and I quite agree with Mr. Benton, I think that it is best, if an indicator is available, to apply it to an engine after the valve setting and adjustments have been made as described in order to check up the setting and to see how close to ideal steam distribution in the cylinder the setting approaches.

Indicator diagrams show whether or not equalization of events at the respective ends of the cylinder actually has been accomplished. In some cases, minor adjustments may be found advisable after the indicator has told its story. Then, too, the indicator diagram serves as a record of correct adjustments for future reference and thus saves the necessity of again going all over the valve gear as described by Mr. Benton. It requires less time and labor to attach an indicator and "take cards" than to check the valve gear all over, which may not be necessary for a long time after the first adjustments have been correctly made.

Brooklyn, N. Y. CHARLES MASON.

Hose Leveling Device

IN THE ARTICLE by John Gaddis entitled, "Simple Leveling Device," in the June 1 issue, he says, "This device is simple and unfailing in accuracy." Having used and recommended this device myself, I agree with Mr. Gaddis that it is an excellent and simple device; however, it is not always "unfailing in accuracy." On my recommendation, a leveler of this type was used in a large factory for leveling shafting. The user was amazed to find that the apparatus was inaccurate and for a long while he couldn't understand why. Presently it was learned that the error was due to the fact that one end of the hose was subjected to a higher temperature than the other and as a result the column of water in the warmer end registered a higher level than the column in the cooler end.

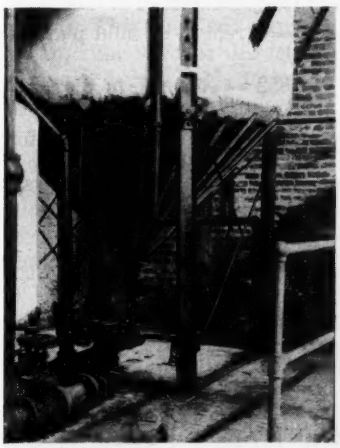
Another thing to be careful about is entrapped air. If the hose is coiled when it is being filled with water, air may be trapped in it and unless all air is out, there will be a difference in level due to that cause. Of course, when held in the position pictured in Mr. Gaddis' article, entrapped air is impossible.

Newark, N. J. W. F. SCHAPHORST.

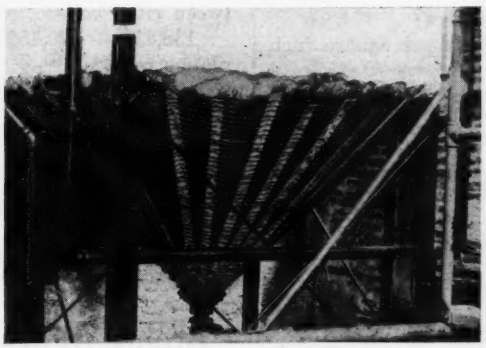
Chicken Wire an Aid in Lagging Tank

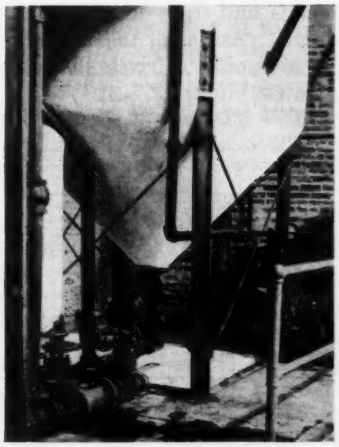
MAGNESIA BLOCKS can be applied nicely to a flat or vertical surface especially where they do not get wet and have to be washed off. Putting them on a tapering surface where they are subject to dirt and moisture and have to be cleaned frequently is, however a different matter.

Lath and chicken wire, used as supports for plastered lagging, on the tapering bottom portion of a water softener and heater in an Iowa power plant is illustrated. Lath was first applied and firmly fastened using No. 16 copper wire to avoid rusting. Over this 1-in. mesh chicken wire was tacked with double pointed tacks. The lagging mixture proportion was 1 lb. of Portland cement to 2 lb. of Johns-Manville asbestos cement. Two layers were put on, first, a ½-in. layer was firmly troweled into the lath and wire; then another ½-in. finishing layer was applied.



LATH AND CHICKEN WIRE ACT AS REINFORCEMENT TO INSULATION COVERING AND HELP MAKE SMOOTH JOB OF IRREGULAR SURFACE





Portland cement was added to harden the coating so that it would stand washing and cleaning. The method used was entirely successful and the finished job presented a very neat appearance.

Missouri Valley, Iowa. FRANK BENTLEY.

Economizer Accidents

ACCIDENTS to economizers are frequently caused by the passing of the hot flue gases around the economizer tubes while no water is circulating through them. This is likely to happen when starting up a boiler, the hot furnace gases being allowed to flow around empty or only partially filled tubes.

Rapid cooling, hence contraction caused by the sudden influx of cold feedwater into the empty tubes that have been heated and expanded by the hot gases, exerts a heat stress on the tubes that may be sufficiently intense to fracture them; in extreme cases they may burst. Such accidents usually occur where the tubes have been wasted by corrosion, the metal being so weakened that it cannot withstand the additional pressure set up.

The remedy against these accidents is not to allow the hot gases to pass around the tubes until water is circulating through them. The boiler dampers should be marked plainly so as to show the proper position for them when no water is passing through the tubes. On no account should the flue gases be allowed to flow around the tubes when the plant is shut down. Operators should be warned against the passing of gases through the economizer before the water circulation is started. Strains set up through the neglect of these precautions have often been the cause of tubes fracturing and in some cases of the parts being badly strained.

Feedwater as delivered to the economizer should not have a hardness of more than 5 to 6 gr., otherwise the tubes will soon become choked with scale. The feedwater delivered to the tubes should not be less than 100 deg. F. in order to avoid external corrosion. If cold water were delivered to the economizer, the outside of the tubes would sweat. This, together with the more or less corrosive flue gases, would cause corrosion. If the feedwater temperature is kept above 100 deg., this sweating will be prevented and the outside temperature of the tubes will be kept above the temperature at which the flue gases will deposit corrosive acids.

While a temperature of 100 deg. is satisfactory where the fuel is not high in sulphur or moisture content, a minimum temperature of 130 deg. should be adopted. Where steam jets are used to provide a draft, the flue gases will contain considerable moisture and so easily cause corrosion. This may be avoided by keeping the feed temperature at not less than 130 deg. as the higher the tube temperature, the less likelihood there is for corrosive action. The outside of the tubes should be kept clear of all dirt and soot, so that heating will be uniform. If parts of the tubes are insulated by soot and dirt, the efficiency of the economizer will be reduced, due to the loss of heating surface.

London, England. W. E. WARNER.

EXTENSIONS to be carried out at the Millfields Road station of the Metropolitan Borough Council of Hackney, London, Eng., will include one turbine-generator and three boilers, while plans have also been made for this additional equipment to be doubled in the near future. The boilers, of the semi-vertical tri-drum type, are each to have a normal evaporation of 125,000 lb. per hr. and 150,000 lb. maximum at 400 lb. per sq. in. pressure and 800 deg. F. steam temperature.

DOUBLE SUCTION centrifugal pump impellers are hydraulically balanced and require only a small thrust bearing or collar.

Questions and Answers

Calculation of Double Butt-Strap Joint

WHERE the tube holes are cut through the plates and butt straps of a double riveted butt joint with two cover plates, how is the efficiency of the joint calculated?

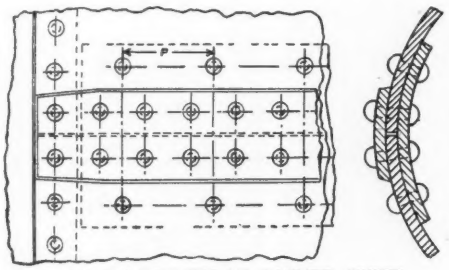
W. H.

A. The method of calculating the efficiency of a double butt-strap joint is best shown by taking an example. Assuming the following definitions:

p = pitch of rivets in inches on the row having the greatest pitch;

t = thickness of the plate, in inches;

TS = tensile strength, in pounds per square inch;



DOUBLE BUTT-STRAP BOILER JOINT

d = diameter of the rivet after driving, or the diameter of the rivet hole;

n = number of rivets in single shear per unit length of joint;

s = shearing strength of rivets, which for iron we can take as 38,000 lb. per sq. in. and for steel, 42,000 lb. per sq. in.

a = the cross-sectional area of the rivet after driving;

c = the crushing strength of mild steel, which we can take as 95,000 lb. per square inch.

The strength of the solid plate = $p \times t \times TS$.

The strength of the plate between the rivet holes = $(p - d) \times t \times TS$.

The shearing strength of rivets = $n \times s \times a$.

The crushing strength of the plate in front of rivets = $n \times d \times t \times c$.

The efficiency of the joint is then found by dividing the smallest of the results obtained for the last three formulas above, by the strength of the solid plate.

Now let us assume a double zigzag butt-joint:

In a double zigzag riveted butt joint, with two cover plates, the pitch of the rivets is 4⅛ in. The rivet holes are 1 5/8 in. diameter, and the plate is ¾ in. thick. If the ultimate tensile strength of the plate is 58,000 lb. and the shearing strength of the rivets is 40,000 lb., what is the efficiency of the joint?

Using the same symbols as above:

TS = 58,000 lb. = tensile strength of plate;

t = ¾ in. = 0.75 = thickness of plate;

p = 4⅛ in. = 4.125 = pitch of rivets;

d = 1 5/8 in. = 0.9325 = dia. of rivet after driving;

a = 0.6830 = cross-sectional area of rivet in sq. in.;

s = 40,000 lb. = shearing strength of rivets.

$p \times t \times TS = 179,452$ = strength of solid plate of unit length.

$(p - d)\ t \times TS = 138,852$ = strength of plate between rivet holes.

$138,852 \div 179,452 = 0.774$ = efficiency of joint for plate strength.

For shearing of rivets, $n \times s \times a = 4 \times 40,000 \times 0.6830 = 109,280$ lb.

Efficiency = $109,280 \div 179,452 = 0.61$.

For crushing of plate, $n \times d \times t \times c = 2 \times 0.9325 \times 0.75 \times 95,000 = 132,867$ lb.

Efficiency = $132,867 \div 179,452 = 0.744$.

The smallest efficiency is that of rivets in shear = 61 per cent.

Bronze Alloys for Heavy Pressures

WILL YOU kindly send me information regarding different alloy mixtures to make hard bronze for a sugar mill top roller bearing carrying a pressure of 4500 lb. per sq. in.? Top hydraulic jacks 13½ and 12 in. diameter are on each top roller, making the total area of both Jackson top rollers, 273.22 sq. in. Journals are 15½ in. diameter and 20⅛ in. long. Shaft rotates 2¾ to 3¼ r.p.m. Bearings are water jacketed. J. M.

A. An alloy of 85 per cent copper, 10 per cent tin and 5 per cent lead will withstand compression of approximately 24,000 lb. on a 1-in. cube at the yield point; a 1-in. cube will compress 26 per cent under a load of 100,000 lb. without fracture. The compressive strength is sufficiently high for it to be used in severe service; it is an admirable alloy for connecting-rod brasses.

An alloy of 80 per cent copper, 10 per cent tin and 10 per cent lead, as compared with the alloy carrying but 5 per cent of lead, shows a diminished resistance to compression, namely, 23,000 lb. of a 1-in. cube at the yield point, and a compression under 100,000 lb. of 29 per cent. This alloy is used for locomotive, car and general machinery bearings. A small percentage of phosphorus is often added and the alloy is then known as standard phosphor-bronze bearing metal. (S.A.E. Specification No. 26—0.05 to 0.25 per cent P.) The phosphorus adds somewhat to the resistance to compression and to the fluidity of the metal but it has not been proved that it benefits in any way the quality of the alloy from the standpoint of service as a bearing.

In fact, the limited data at hand tend to show that it acts adversely in service, because of the production of the brittle phosphide of copper in the alloy which frequently tends to cause heating. This alloy, nevertheless, is called for in the specifications of many prominent consumers and may serve your purpose well because of the slow speed and apparent absence of severe shock.

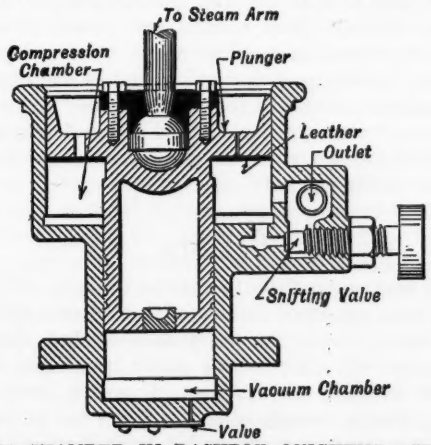
An alloy of 77 per cent copper, 8 per cent tin and 15 per cent lead is extensively used, and together with a small percentage of phosphorus (0.2 per cent) is known on the Pennsylvania Railroad as Ex. B. metal. This is the alloy of highest lead and lowest tin content which Dr. Dudley was able to produce, owing to foundry difficulties. Alloys of lower tin and higher lead segregated, the lead liquidating to the bottom of the casting, due probably to the presence of phosphorus which lowers the solidifying point of the alloy and therefore maintains the alloy in a liquid condition for a longer period. This alloy will support a load of 21,000 lb. on a 1-in. cube without distortion. It has a slow rate of wear and is less liable to heat in service than either of the two preceding alloys.

Alloys containing from 4 to 7 per cent of tin, and 20 to 30 per cent of lead, are known in the trade as Ajax plastic bronze alloys. The patent controlling these alloys is based upon the fact that lead which is only mechanically held in the alloy can be prevented from liquidating to the bottom of the casting if the copper and tin matrix which will result if the copper and tin are in correct proportions, that is, in such plastic bronzes of various grades are in use very extensively for locomotive and car bearings, cold-roll neck mill bearings.

Dashpot Construction and Operation

How are dashpots, such as those used on Croliss engines, constructed and how do they operate? W. H.

A. Dashpots used on Corliss engines consist of two concentric cylinders of different diameters. In the upper and larger of these cylinders is fitted a piston having a



VACUUM CHAMBER IN DASHPOT QUICKENS ACTION OF CUTOFF; AIR CUSHIONS DROP TO ELIMINATE NOISE

central projecting portion that extends downward and forms a plunger, which plunger fits the lower and smaller cylinder. The upper cylinder has an opening in its end that may be regulated by a valve or cock. This opening is placed so as to be a short distance above the lower edge of the piston when it is in its lowest position; it allows a small quantity of air to enter as the piston rises and this air checks the downward motion to an extent depending on the amount of opening of the valve. After the lower edge of the piston descends until the opening is covered, the further escape of air is prevented and the air remaining in the cylinder acts as a cushion that prevents the piston from striking the bottom too violently.

Comparative Electrical Conductivity of Different Metals

Recently I heard that aluminum is a better conductor of electricity than copper. Is this correct? What metal is the best electrical conductor and what are the relative electrical conductivities of different metals?

F. V. G.

A. From the table, it will be seen that pure aluminum has a conductivity of only 63 per cent of that of annealed copper. Commercial aluminum, which is 97.5 per cent pure, has the corresponding percentage of 59.8 per cent.

Metals	Resistance of 1 cir. mil-foot in ohms		Av. temp. coefficient per deg. F. between 32° and 212° F.	Percentage Conductivity	Relative resistance
	32°	75°			
Silver, pure annealed	8.831	9.674	0.002220	108.60	0.925
Copper, pure annealed	9.390	10.351	0.002360	102.10	0.980
Copper, annealed	9.590	10.505	0.002250	100.00	1.000
Copper, hard-drawn	9.810	10.745	0.002230	97.80	1.022
Gold (99.9% pure)	13.216	14.404	0.002090	72.55	1.378
Aluminum (99.5% pure)	15.219	16.758	0.002350	63.00	1.587
(Commercial-97.5% pure)	16.031	17.699	0.002420	59.80	1.672
Zinc (very pure)	34.595	37.957	0.002260	27.72	3.608
Iron, (approx. pure)	54.529	62.643	0.003470	17.50	5.714
Iron "E.B.B." iron wire	58.702	65.190	0.002570	16.20	6.173
Platinum (pure)	63.670	71.418	0.002038	14.60	6.845
Iron, "B.B." iron wire	68.680	76.270	0.002570	13.50	7.407
Nickel	74.128	85.138	0.003460	12.94	7.726
Tin (pure)	78.489	86.748	0.002450	12.22	8.184
Steel (wire)	81.179	90.150	0.002570	11.60	8.621
Alloys					
Brass	43.310	.....	.....	22.15	4.515
Phosphor-bronze	51.005	.....	0.000356	18.80	5.319
Aluminum bronze	73.989	.....	0.000556	12.96	7.714
German silver Cu 50, Zn 35, Ni 15.	127.800	.....	0.000220	7.50	17.300

ELECTRICAL RESISTANCES AND TEMPERATURE COEFFICIENTS OF CERTAIN METALS AND ALLOYS

As shown, pure annealed silver is the best electrical conductor ranking as 108.6 per cent as compared to annealed copper. It is interesting to note that platinum is a rather poor electrical conductor.

W. Winger, Ottumwa, was elected president of the Iowa department, National Association of Power Engineers, at the closing session of the 27th annual state convention in Sioux City, Iowa, succeeding W. W. Gasser, Sioux City. Ottumwa was awarded the 1931 meeting. Other officers for the year are: J. A. Murphy, Des Moines, vice-president; C. A. Bland, Des Moines, reëlected secretary; Charles Amos, Sioux City, treasurer; J. Croskey, Davenport, reëlected conductor, and Dale Hicks, Marshalltown, doorkeeper. Among speakers at the session were: Jack Smith, Des Moines, president of the Iowa coal miners, who urged use of Iowa coal; J. Rosboro, Bixby Co., Des Moines; George Barnes, Anchor, Des Moines; and J. E. Welsh, Viscosity Oil Co., Des Moines.

In steam engines, low superheat effects greater improvement than in steam turbines, because of its influence in preventing cylinder condensation.

Editorial Comment

South Amboy Station

When we say, in the title of the leading article in this issue, that South Amboy is different, we mean to express the most impressive characteristic. It is different in a progressive original way, yet careful study of the details shows that the differences are caused only by carrying the design of each of the various items to its logical conclusion on an entirely sound engineering basis.

For example, use is made of coal silos, to eliminate overhead bumpers, save steel work, lessen hazards and allow the coal to flow by gravity direct from silo to pulverizer feeders. The silo for coal storage has been successfully used before; it is the particular application of it here that is different. Use of direct contact extraction heaters is dictated by the desire to reduce heat losses and eliminate drip pumping and cascading. Such heaters have been used before for heating water. Combustion control system to measure coal and air before they reach the burners is a logical step in the development of close control of the combustion process. Use of 1200 lb. pressure, desuperheater, slag tap furnace has been justified by previous experience in other plants. The space economy of the vertical-compound turbines has been demonstrated. Placing the live steam reheater near the boiler saves 1400-lb. steam piping. Thus one can see that each detail is the result of sound engineering analysis. We might cite many other instances.

It is the incorporation of so much of this progressive thinking in the details of one plant that produces the impression of "differentness." They are not experimental, because so many of the principles have been used one at a time elsewhere. The aggregation of them in one plant and the care and attention in working them out to meet these particular conditions are the things that arouse interest.

Results secured in the design at South Amboy were obtained by the utmost freedom and coöperation between the engineers and the manufacturers of the equipment selected. There was no tendency on the part of the engineers, it is stated, to curtail unnecessarily the ability of these manufacturers to produce the best equipment available for the services required.

In short, judging South Amboy by present standards of central station design, we feel that it represents a long step forward in the art. The high-pressure equipment, as has already been shown, does much to forestall obsolescence and the sound engineering of the details should lead to high operating economy. There is every reason to believe that it will play an important part in the great drive of the industry for more system capacity per dollar of investment. South Amboy, in our opinion, is the outstanding central station of the year.

Flood Control

Flood control and water power developments do not as a rule go hand-in-hand. Storage reservoirs for power purposes usually being full in the spring of the year when floods are more common, are of little service or value for checking stream flow.

Occasionally, however, floods come at unexpected seasons, catching entire states unaware and doing much more damage than if they arrived during the period when high water is expected. Such a condition existed in the New England flood of a couple of years ago. The highest recorded rainfall was 9.65 in. at Somerset, Vermont, but was undoubtedly higher in some of the mountainous areas.

In general, the flood flows reached a maximum runoff of more than 100 sec. ft. to the square mile of drainage area while several determinations showed floods of from 300 to 500 sec. ft. per square mile. Losses to the railroads alone exceeded $13,000,000 in New England and the total losses probably reached $40,000,000, over half of which was in Vermont.

Effects of the storage reservoir were apparent especially in the southern districts where the streams are well developed for power purposes. At many points, the flood flow was reduced because the reservoirs did not spill until the crest of the flood had passed in the rivers below. An excellent example of the effect of reservoirs on the flood flow was shown by records for the Deerfield River where storage in the Somerset and Davis Bridge reservoirs reduced by fifty per cent the effective flood area of the river at Charlemont, Mass.

Thus, although flood control and power project requirements are at times antagonistic, power projects do give a good measure of protection against such disasters at unexpected times. In this one instance, many of the developments undoubtedly reduced the property damage sufficient to pay for all or at least a part of the development cost of the project.

Off Duty

Who among us fails to remember how, when still very young, we were fascinated by a mysterious toy which usually made its appearance around Christmas time—a sort of a top which could be set in rotation and then balanced on a string. It was a curious contraption, simple enough in construction for it consisted of only a couple of rings and a little flywheel but its behavior was beyond understanding; uncanny. It would stand balanced, motionless in any position it was placed but if an attempt was made to force it to one side or the other, it would resist the applied force as though endowed with a will of its own. It never would do what you wanted it to do. As mysterious as its behavior was its name, for it was called a gyroscope.

But if our child minds were puzzled by the per-

formance of this curious toy, our elders were little better off. They could tell us little about it; in their usual bluffing way, they may have looked wise and informed us, learnedly, that the reason it acted as it did was because it was a gyroscope. Gyroscopes always acted that way. Simple, indeed, but what of it? What was a gyroscope?

As we grew older we were destined to hear more of the gyroscope. The device, it seemed, was of practical use; a man by the name of Sperry had made a compass out of it to steer ships by—a gyro-compass he called it. Later he used it to stabilize ships and airplanes. More mystery! How could a spinning top act as a compass? How could it prevent the rolling of a ship?

Today, though we are reasonably familiar with the gyro-compass and the gyro-stabilizer we still don't know a great deal about the way it accomplishes its uncanny feats. A tiny spinning wheel in a well protected steel housing on board a battleship—yet this simple device guides the great ship across the trackless ocean as unerringly as though its course were marked by sign posts. In the form of the "Metal Mike" or the gyro-pilot, the gyro-compass steers the ship without human intervention. Most of the great liners in our merchant marine today make their way across the seven seas under the guidance of this automatic helmsman. It holds their way on a straighter course than ever human hands could steer them for, strange as it may seem, they are steered by the steady and unfailing rotation of the earth itself.

It is to the inventive genius of Elmer A. Sperry that the world owes the gyro-compass and the gyro-stabilizer. Through years of study and unremitting effort, Elmer Sperry forced the gyroscope to give up its secrets. To him the little spinning top told of its wonderful sixth sense, so to speak, which enabled it to feel motion around a center, no matter how remote this center might be—even if it is the center of the earth, 4000 miles away. That, indeed, is the secret of the gyro-compass; the ability to detect the earth's motion around its center 4000 miles from the surface. Knowing these secrets Elmer Sperry proceeded to apply them to the benefit of mankind and in that, no man ever succeeded better.

But it was not alone for his transformation of the gyroscope from a scientific toy into a stabilizer of ships and a device for guiding our leviathans across the seas that Elmer Sperry was known to the world. Long before anybody ever heard of a gyro-compass his inventive ability had attracted attention. When but twenty years old he had several inventions to his credit, chief among which was a dynamo and arc lamp that showed such promise that capital was secured for an undertaking known as the Sperry Electric Co., in Chicago. At that time one of his notable achievements was a beacon of arc lamps, on the tower of the Chicago Board of Trade, with an aggregate illumination of 40,000 candle power.

Sperry's achievements in this field of arc lighting are almost as well known as his work on the gyroscope and today his high intensity searchlight is in use by military and naval forces throughout the world. In one step, he produced a practical light with an intrinsic brilliancy fully five times that of its best predecessors. Its high brilliancy was due to the use of carbons with a mineralized core the vapor from which attained a temperature of some 6000 deg. C., practically that of the solar surface.

A natural born inventor and machinist, aided by an excellent training in the groundworks of mathematics, Elmer Sperry's inventions and enterprises covered a wide range extending from beacon lights of many kinds, mining machinery, street cars, automobiles, airplanes, commercial chemistry, production of fuse wire, gyroscopes and Diesel engines to his last as perhaps most remarkable invention, the metal flaw detector.

This last device reflects his remarkable versatility as an inventor. It was developed primarily to detect flaws in rails and is based on the fact that flaws increase the resistance of a rail to the passage of an electric current. As the car carrying the detector moves along the rail, any departure from normal conditions is automatically recorded on a chart and at the same time a device underneath the car marks the point where the flaw exists by squirting a stream of white paint against the side of the rail.

This ingenious equipment was developed within a few years of Sperry's seventieth birthday. For forty years he labored incessantly, never tiring, no hours too long or no personal sacrifice too great to accomplish his end. Never caring for the conventional methods, he was essentially a pioneer; one of great versatility and originality. Over 400 patents stand to his credit.

His inventive genius, however, was only one side of Elmer Sperry's personality. Over and above these practical qualities, he possessed a kind and sympathetic nature. With all his varied activities and heavy responsibilities he never lost the human touch—he was always sympathetic and helpful to those associated with him and was never too busy to devote a few minutes of his valuable time to the visitor, no matter how trivial his mission.

Last month Elmer Sperry went "Off Duty." His gentle personality will be seen no more at the gatherings of the many scientific and technical organizations in which he was active, but it will long be remembered by those who knew him. His life was rich in friends and if, in his death, the world lost a great inventor, a benefactor to mankind, his friends lost something even more rare: a kind, charming personality.

RECLAIMING the sensible heat of hot coke has been successfully accomplished. One such installation, operating on the dry quenching principles, uses a steam boiler to reclaim this heat by generating steam for power purposes. The coke, coming from the oven at about 1800 deg. F., is cooled by inert gases circulated through the coke and passing to a boiler where they are cooled and forced back to the coke again in a closed circuit.

In a 1000-t. a day plant, 860 lb. of 140 lb. steam is made for each short ton of coke cooled. The feedwater temperature is 180 deg. F. and the coke leaves at from 350 to 400 deg. F. Neglecting the heat in the outgoing coke over 80 per cent of the heat is recovered, or considering the total heat, about 70 per cent is recovered. The fan requirements amount to 2.14 kw-hr. per t. of coke cooled and the skip hoist requirements per ton of coke cooled amounts to 0.14 kw-hr. on the same basis.

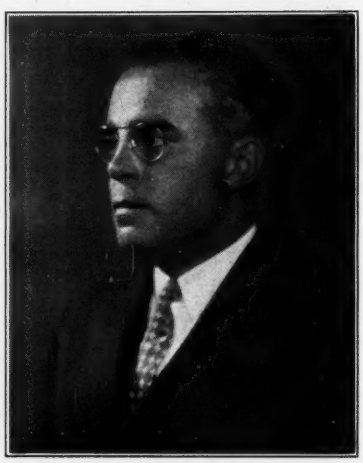
Power Plant Engineering Developments and News

N.E.L.A. Meets at San Francisco

REPRESENTING A considerable proportion of the Executive and Technical brains directing the electric utilities of the United States, 4000 delegates to the 53rd convention of the National Electric Light Association gathered in the Exposition Auditorium in San Francisco on Tuesday, June 17.

While the convention was in progress, the event was signalized by a city-wide scheme of special lighting, with the major effects concentrated at the Civic Center. The aggregation of equipment is declared by illumination authorities to be the largest and most costly ever brought together on the Pacific Coast for a temporary installation.

At exactly 8:52 on the evening of June 16, an airplane zoomed down over the Civic Center with a siren sounding, which operated a supersensitive relay mounted



NEW OFFICERS OF THE N. E. L. A.

Top row, left to right: J. F. Owens, vice-president (photo, Blank & Stoller, Inc.); W. A. Jones, president (photo, Underwood & Underwood); Edwin Gruhl, vice-president. Lower row: P. S. Young, treasurer (photo, Blank & Stoller); Paul S. Clapp, managing director; A. Jackson Marshall, secretary (photo, Underwood & Underwood).

on one of the transmission towers which, in turn, flashed on one of the most spectacular and ambitious programs of flood lighting ever arranged on the Pacific Coast.

On a grass covered area across the street from the library was a small modernistic pavilion in which was mounted the 50-kw. General Electric incandescent lamp, the largest incandescent lamp in the world, said to give forth a light equal to that of 6000 of ordinary size and power. It is an experimental achievement of the General Electric Laboratories. The huge lamp was flashed at intervals, remaining lighted for only 15 sec. at a time in order to guard against injury to the eyes of spectators.

It is estimated that fully 25,000 people were in the Civic Center when the elaborate lighting system was turned on Monday evening, June 16.

Sloan Deplores Attacks on Public Utilities

Mathew S. Sloan, president of the Association and president of the New York Edison Co., in opening the convention, deplored the fact that public utility laws and the machinery of public utility regulation "are being recast amid a clamor of extremist theories, demagogic attacks and political maneuverings. We are told by newspapers," he said, "that the 'utility issue' is to be a feature of coming state elections, and perhaps, of the next presidential election. This is eminently undesirable and is not in the public interest. Economies will not be promoted thereby. Sales will not be increased thereby. Rates will not be lowered thereby. Capital will not be made more available thereby.

"What is needed now and for the future," he continued, "is not heat or hate or demagogy but the application of economic principles through laws protecting the public without penalizing the utilities. Laws which will command and reward the confidence of the investor without robbing the consumer."

Discussing the part which is being played by the light and power industry in the unified effort of business to overcome the effect of last fall's stock market crash, Mr. Sloan said that the latest information indicates an expenditure of $1,046,000,000 during this year for extension of service facilities. "One billion dollars to buy equipment and material and pay wages to workers all over the land, making business for others, and sustaining the purchasing power of the customers of every variety of trade; and this was a figure, if you please, not reached by any forced or extraordinary circumstances but merely a tabulation of our annual progress in supplying this country's needs for electric energy.

"It is only when our attention is focused dramatically on the evidence of our growth, as in this instance, that we are able to grasp its full significance and the vital importance of our industry in the economic scheme of things."

In closing, Mr. Sloan called for the framing of proper regulatory laws, saying that the industry could be counted upon to coöperate. "Fair, impartial, courageous administration of such laws can be obtained," he said. This is a land in which progress, both in business and government, is constantly being achieved. Because a fair deal for the public inevitably involves a fair deal for the utilities, I am convinced such laws and such administration of them will be worked out by the good sense of the American people."

Must Eliminate Popular Misconceptions

Speaking on the subject "Let There Be Light," Merle Thorpe of Washington, D. C., Editor of Nation's Business, declared that "in order to get light into more electric bulbs, there must be more light in the public discussions of light and power. No industry has more popular economic fallacies built around it than the electric light and power industry," said Mr. Thorpe. He called attention to 10 of the most fallacious.

After reviewing the benefits which the development of the light and power industry has brought to the people of the United States, Mr. Thorpe attacked criticism of the industry, saying, "This criticism, strange to say, comes not from the 20 million users of electricity. When they remember that their light and power bill is less than $3 monthly, it is pretty difficult to get them excited. The criticism comes from those who ought to know better. The complaint is that the future job should be done differently and they are advocating the new set of rules for the future. Fireside critics who don't know the North Pole from an electric light pole and blind to the amazing picture of what has been done, cast a deprecating eye at the machinery and opine that it could have been done better in some other way."

Taking as his theme the thought that "the sin of silence is sometimes a dangerous sin" and quoting the elder Rockefeller as saying that "next to doing the right thing, the most important thing in the world is to let people know that you are doing the right thing," Harry Reid, chairman of the Public Relations National Section, made a strong plea for more and better publicity with regard to the known facts concerning the light and power industry.

Trend in California Is Away from Hydroelectric Development

The trend of power generation in California away from hydroelectric development and toward steam plants, and the continued increase in the cost of new construction, were the two chief characteristics of the discussions at the Engineering Section Session on Tuesday afternoon.

Speaking on "The Future of Water Power Development in California," A. H. Markwart, vice-president of the Pacific Gas & Electric Co., said: "Under the circumstances which now prevail, it is natural to question the future of hydro power in California, despite the fact that hydro development has been actively prosecuted for more than four decades to the economic advantage of the state."

One of the outstanding reasons which he gave is the constantly mounting cost of water power development, "because, as a general thing, the remaining sites cost more to develop and are less accessible than those sites which have already been developed." In his opinion, a combined hydro and steam system can generate "mingled energy" more cheaply in California than could one generating all energy from either source alone, provided the load factor is fairly high.

F. B. Lewis, vice-president of the Southern California Edison Co., discussing the Trend of Power Generation in Southern California, said that insofar as his company

is concerned it is "definitely toward the use of steam generating equipment for additional plant expansion, and has been so for the past five or six years to an increasing degree."

A. H. Kehoe, electrical engineer of the United Electric Light & Power Co., New York, stressed the urgency for aggressive action by engineers because of the trends of costs. "While the situation is not yet critical," he said, "the ominous sign on the technical horizon is the continued increase every year of the average dollars invested in our systems for each kilowatt of generating capacity."

Presenting a graphic word picture of the progress of the electric light and power industry during the past 5 yr., Paul S. Clapp, managing director of the National Electric Light Association, said that "these 5 yr. have witnessed the most startling and rapid advances in the history of the world."

"Since we met here in 1925," he said, "five and a half million new customers have been added. More than five million of these are homes. With four persons to the average household, this means that electric service has unfolded to 20 million persons, or 17 per cent of the present population of the country. In these 5 yr., population grew 4½ per cent; the aggregate use of electricity in homes increased 70 per cent, indicating the stupendous movement now under way toward home "electrification."

A forceful word of warning was brought to the convention from outside the electrical industry by Fred W. Sargent, president, Chicago & North-Western Railway Co., who drew on a rich experience in the railway industry to caution the utilities to safeguard the investments of their customer-owners by every possible means. He cited the difficulties following the financial depression of 1873 that beset the railroad industry, when losses on investment created a resentment against that industry, throughout the country which took years of the most careful and cautious management to overcome.

In times of depression such as the country is now emerging from, he said, the demagogues thrive and the stage is set for possible burdensome legislation, which can be forestalled by able management and by showing the public that such management produces results advantageous to the public.

A holding company's value in the utility business and the relation of accounting to management were discussed, respectively, by M. A. Morrison, vice-president of H. M. Byllesby Co., Chicago, and Franklin T. Griffith, president, Pacific Northwest Public Service Co., Portland, as subjects of prime interest to the Accounting Section Session Tuesday afternoon, June 17.

A picture of a highly experienced president, seven or eight vice-presidents, and several hundred other persons, consisting of engineers, accountants, and rate and valuation experts, centering their attention on some little cross-roads village of 895 people in order that the work done by two or three members of a household might be done by one, was presented by Mr. Morrison.

Mr. Morrison is strongly of the opinion that without holding and management companies, without interconnection of transmission facilities, and without a marked broadening of service, together with continued reduction in rates, rural communities now enjoying dependable and uninterrupted electric service would not have been able to obtain this service for many years to come.

Repeating the story of the banker and the baker who lived happily for many years because the banker agreed to bake no pies and the baker agreed to cash no checks A. W. Robertson, chairman of the Board of the Westinghouse Electric & Manufacturing Co., drew a sharp line between the rights and duties of electrical manufacturers and those of public utility men in his address before the Second General Session Wednesday, June 18.

"If some simple definition could be worked out," he said, "So that manufacturers would not be cashing the public utility checks and the public utility would not be baking the manufacturer's pies, they might profit substantially."

Mr. Robertson insisted that the men who control the destinies of the electrical industry are well disposed toward the world and that "it is a most sincere compliment to these men that, notwithstanding the clamor in Washington, there is little criticism to be found locally against electric utilities.

Speaking on the subject of "The Future of the Electrical Industry" before the Second General Session on Wednesday, June 18, W. A. Jones, chairman of the Executive Committee of Henry L. Doherty & Co., executive vice-president of the Cities Service Co. and first vice-president of the Association, reminded his audience that in 1879, a professor in one of our great schools of technology stated: "After a thorough investigation, I find that the electric light is a failure." To which Mr. Jones added: "and yet, before the results of his investigation had been made known to many people, Mr. Edison had proved him a false prophet."

He then told an amusing story of the managing editor of a great metropolitan newspaper, who, on seeing an account in his columns reporting upon Edison's perfection of the incandescent lamp, flew into a rage, saying: "That kind of a light has been demonstrated to be against the laws of nature and this newspaper will be a laughing stock because it has fallen for such a yarn."

Warning his audience that America had better "stop, look and listen," Edward N. Hurley, former chairman of the United States Shipping Board, said that "instead of flattering ourselves that we are in a position now to indulge in all kinds of luxurious experiments, we had better be stripping for action. Were it not for the fact that some of our foreign competitors for international trade have previously handicapped themselves by socialistic experiments, which we are now urged to adopt, our position already would be much worse than it is."

World-Wide Communication Session

Between 12 o'clock and 12:45, Pacific Standard Time, on Wednesday, June 18, Thomas A. Edison, sitting in his laboratory at West Orange, New Jersey; Lord Derby, in a studio in the suburbs of London; Dr. Carl Koettgen, presiding at a banquet given to the delegates of the World Power Conference in Berlin; Dr. Oskar von Miller, honorary chairman of the World Power Conference; Senator Guglielmo Marconi, in London; Matthew S. Sloan, presiding at the Second General Session of the N.E.L.A., and Owen D. Young, chairman of the Board of General Electric Co., both in

San Francisco, faced microphones and addressed each other and the whole world by means of the greatest international hookup of radio, telephone and telegraph land wires and submarine cable ever attempted.

It was a dramatic event in the history of communication. Phillip Carlin of the National Broadcasting Co., master announcer, standing at the microphone before the delegates to the N.E.L.A., opened the affair with a brief explanation and a roll call to which London, Berlin and West Orange responded through their announcer. Matthew S. Sloan, president of the N.E.L.A., was introduced and he addressed the World Power Conference in Berlin.

Regulation of Utilities

Regulation took the stage on Thursday, June 19, at the third general session, with Martin J. Insull; William A. Prendergast, W. C. Langley & Co., New York City, and W. J. Hagenah, vice-president, Byllesby Engineering & Management Corp., Chicago, Ill., discussed various phases of this subject.

Calling attention to the fact that in the early days of the light and power industry the financial structure of the small local companies was generally too weak to secure the new capital necessary to meet the ordinary growth of the business, Martin J. Insull upheld the holding company form of corporate organization.

Speaking specifically of the development of the holding companies in the electrical industry, he said: "Had the holding companies not found the necessary financial resources to carry on, the history of the electric light and power industry—and I feel justified in saying on behalf of that industry, the history of the industrial rise of the United States as well—might have been written very differently."

William A. Prendergast defended the system of state regulation of public utilities, insisted that it has protected the public interest and asserted that there are no serious indications that the people have any intention of abandoning it.

Edwin Gruhl, vice-president, National Electric Light Association, presented some striking comparisons between the value of the electric dollar and the value of other dollars, such as the clothing dollar, the food dollar, the rent dollar and even the business-of-government dollar.

Referring humorously to the present size of the paper dollar bill, Mr. Gruhl said: "It seems that the new dollar bills have been cut to a size corresponding to what they would buy now as compared with 1914," to which he added that the present dollar has a purchasing power of but 58 cents in buying the ordinary necessities of life, as compared with the dollar of 1914.

Describing the series of almost uninterrupted annual reductions in the average price of a kilowatt-hour of electricity, he said: "Due to this lowered price, the electric dollar in the home now has a buying power of $1.36, more than double the buying power of the 58-cent cost of living dollar."

In addition to these addresses, on Thursday, June 19, various prize awards were presented by W. H. Onken, Jr., of Brooklyn, chairman of the prize award committee, and Franklin T. Griffith, president Pacific Northwest Public Service Co., Portland, Ore. Mr. Griffith, who was president of the association in 1925, when the Bonbright prize was awarded for the best essay reviewing the accomplishments of the electrical industry for the past 5 yr. and predicting its accomplishments for the next 5 yr., presented the American Superpower Corp. prize for the essay written in the contest 5 yr. ago that has proved to have been the best prognostication of the actual accomplishments during the period from 1925 to 1930.

Message Sent Around the World in 5½ Minutes

Owen D. Young presented the address of the evening at the Public Policy Session in the Auditorium the night of Thursday, June 19. The National Broadcasting Co.'s concert Orchestra with Charles Hart Conductor gave a concert, to which the public was admitted. The entire program for the evening was broadcast over the National Broadcasting Company network locally by KGO.

As a feature of the evening, a telegraph message was dispatched around the world by the Postal Telegraph-Cable Co. The message was dispatched from a sending instrument on the Auditorium stage and traveled over 30,000 mi. of telegraph and cable lines by way of Shanghai, Sineria, London and New York in an attempt to break the present record of 8 min. The receiving set was also located on the stage. The 38-word message was sent around the world in 5 min. and 32 sec. The performance staged before approximately 7500 persons gathered in the Auditorium startled electrical engineers and spectators.

Presenting the annual report of the Engineering National Section, N.E.L.A., A. D. Bailey of the Commonwealth Edison Co. of Chicago and chairman of the Section said that the engineer has had to insert himself in the human engineering and dollar engineering features of the development of the light and power industry as well as in purely technical subjects.

Discussing the question of coöperation which exists within the industry, he said: "We have a great advantage in the fact that we are noncompetitive and because of that fact we are free in the exchange of information between individuals and companies. It is to our mutual advantage to keep the industry as a whole up to the highest possible plane. In no other industry will you find groups of men from all over the country getting together, working together and exchanging information as is done in this organization. No other industry presents the united front and sets the fine example which this organization has presented to industry in general and to the people of our country."

W. A. Jones, New President

The convention was concluded by the elevation in position of the following officers: W. A. Jones, president; J. F. Owens, vice-president; Marshall E. Sampsell, second vice-president; Edwin Gruhl, third vice-president; Paul M. Downing, fourth vice-president. Mr. Downing's selection is considered a tribute for his efficient work in connection with the present convention.

There is always a liberation of heat when substances combine chemically and the more violent the reaction and more staple the compound, the greater the amount of heat liberated.

Spray Painting Equipment

SEVERAL NEW TYPES of spray equipment have recently been placed on the market. Two types of spray painting equipment are known as Outfits No. 222 and No. 333.

Both operate from the air pressure of any auto, truck, or tractor without the use of an air compressor. The Binks air-pressure valve is inserted in any spark plug opening and the motor is run idle, thereby producing a free passage of air through the valve on the downward stroke of the piston. The upward stroke compresses the air and forces it through the spray gun.

Outfit No. 222 is complete with No. 22 spray gun, air-pressure valve and 25 ft. of air hose. The No. 22 spray gun has a sturdy cast aluminum cup holder attached to a standard pint Mason jar. The No. 333 outfit consists of the No. 33 spray gun, pressure material cup, two air-pressure valves and 25 ft. of air hose.

Another product, the Big Four, designed to operate from the engine of any automobile, truck or tractor, consists of four separate interchangeable products: the No. 33 spray gun; No. 160 oil gun; No. 161 car washer and a No. 163 tire chuck. They connect with the air-pressure valves as described above.

No. 160 oil gun not only serves to lubricate, by pressure, springs and all parts of mechanical apparatus, but is also used as an engine and chassis cleaner. It is designed to eliminate fire hazard by operating from an enclosed cup gun and not fed by an open container.

No. 161 car washing gun is constructed entirely of brass and has an adjustable nozzle and standard connections for city water lines. The air chuck is of standard size and designed to inflate any tire.

The new Thor 2-E portable outfit, Fig. 2, has been manufactured to meet the requirements of master painters and builders. It is designed to be easily portable, of sufficient size to produce good work at high speed and to operate from any light socket.

The air compressor unit is belt driven by a ½-hp. General Electric motor. It has an air displacement of 3.5 c.f.m. This complete outfit is equipped with the No. 345 spray gun; 2-gal. pressure material contained and the necessary lengths of air and material hose.

FIG. 1. RU-RO OUTFIT DESIGNED TO OPERATE FROM AUTOMOBILE ENGINE

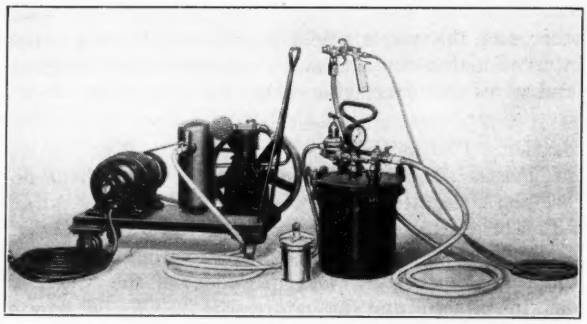


FIG. 2. PORTABLE OUTFIT WITH MOTOR-DRIVEN COMPRESSOR

The Hu-Ro painting outfit, Fig. 1, another new product, is also intended to operate from any auto, truck or tractor engine by use of the air valves described above. This outfit is designed for applying paints, lacquers and varnishes to all surfaces.

It is a complete unit equipped with a container which accommodates a 5-gal. can of paint; a check valve on the container; 25 ft. of air hose; 25 ft. of material hose between the gun and container; has the No. 33 spray gun noted above. The double valve hookup has 25 ft. of ⅜-in. air hose with Y connection and two 3-ft. lengths of hose with valve connections on each end. These are products of Binks Mfg. Co., 3114 Carroll Ave., Chicago, Ill.

Heavy Belt Conveyor

ESSENTIAL FEATURES of this heavy belt made by the Robins Conveying Belt Co., New York City, are as follows:

54 in. wide, stepped-ply construction
16 plies at the side
14 plies at the center
Top Cover—$\frac{13}{32}$ in. thick
Duck—42 oz.
Thickness—1¾ in. (total)
Length of Conveyor—700 ft. center to center
Lift of conveyor—147 ft.

Handling 1950 t.p.m. discharge from 60 in. primary crusher, maximum pieces 15 in.

The conveyor was shipped in three rolls, weighing 21,000 lb. each and spliced on the field in a vulcanizing

THREE ROLLS OF 54-IN. BELT FOR CONVEYOR

press to make an endless belt. In spite of its thickness, the belt troughed perfectly without a load when installed, it is reported.

For this conveyor there was designed a special tandem drive, each 84 in. pulley being driven independently by a 250 hp. motor.

Special 54-in. Timken Bearing idlers were designed by Robins engineers for this belt. These idlers have malleable iron brackets, cast-iron pulleys and end-lubrication to all bearings.

This belt is stated to be the heaviest, thickest conveyor belt ever used. It is installed in the new screening plant of the Michigan Limestone & Chemical Co.

Propeller-Type Forced-Draft Blower

AN ARTICLE in the Journal of the American Society of Naval Engineers recently described tests made at the United States Navy Experiment Station of a Westinghouse turbine-driven propeller-type forced-draft blower. This blower was rated at 75,000 cu. ft. at 10-in. water static pressure, and, it was claimed, proved itself to be of remarkable reliability

THIS 8500-C.F.M. PROPELLER BLOWER IS DRIVEN BY A STEAM TURBINE

and simplicity, unusually low in weight and high in efficiency.

A similar Westinghouse turbine-driven, all-electric-welded steel propeller-type forced-draft blower fan is shown in the accompanying illustration. This blower was recently developed for tug boat firerooms. It is rated at 8500 c.f.m. at 2½-in. water static pressure. The propeller is three-bladed and is driven by a single-wheel turbine, having inside buckets milled in the wheel through a steel shaft supported in grease lubricated ball bearings.

These blowers are designed to be installed in a horizontal or vertical position or at any angle and may be obtained with round, square or rectangular discharge duct. The blower and drive, as illustrated, have an actual weight of only 300 lb.

These new-design blowers are stated to function with freedom from objectionable noise.

These blowers were designed by H. F. Schmidt, consulting engineer, and are manufactured at the South Philadelphia Works of the Westinghouse Electric & Manufacturing Co.

Traveling Screen of New Design

TRAVELING WATER SCREEN embodying new features will be put on the market by the Chain Belt Co., Milwaukee, Wis., this month. While the general principle of traveling water screens will be maintained,

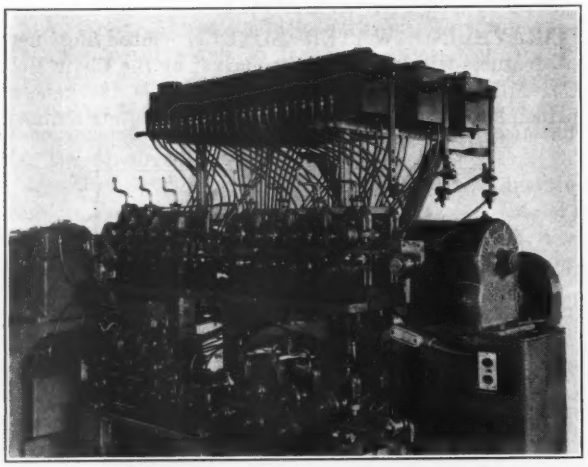
GENERAL ARRANGEMENT OF NEW TRAVELING SCREEN

the outward appearance of the screen itself has been definitely changed. It is designed to occupy small space and to operate at a greater degree of efficiency than the ordinary type of water screen. Two major improvements consist of a new basket design and a new base. Rectangular baskets hold the screen cloth (which may be of various constructions) and are in turn carried by two strands of Rex Chabelco hardened steel roller chain. The chain operates over head and foot sprockets. As the submerged screen surface becomes matted with the refuse, the screen is revolved. The refuse is then lifted from the intake by the upward travel of the baskets and is automatically removed by a powreful spray of water directed though the baskets from the rear, washing this refuse into a refuse trough, as shown. The spray of water serves to sluice the screen material away for disposal, usually on the down-stream side of the plant.

The second major improvement is the new design of the foot wheel to permit the use of the new extended track shoe. This shoe engages the roller at the exact instant that it leaves the wheel. There is no intervening space in which the roller can weave inward to cause openings between the ends of the baskets and the frame of the screen.

Force Feed Lubrication for Expensive Machinery

ACCOMPANYING illustration shows a battery of three 24-feed, McCord mechanical lubricators, as used on one of the machines that form the tubes for tubular type automotive radiators. Using this battery of lubricators the 72 bearings on this machine are completely covered with a thin film of oil all the time they are moving. Accurate and positive delivery of this oil is important because it protects the bearings against corrosion, acid and acid fumes, besides offsetting friction.



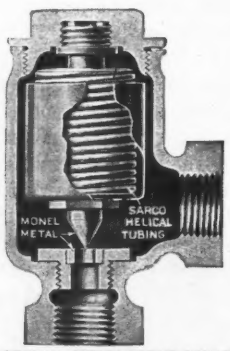
THREE 24-FEED LUBRICATORS ON A TUBE FORMING MACHINE

Approximately 250 ft. of copper tubing is used in connecting the feeds to the lubrication points. To stop any waste of oil an inexpensive reduction gear is used. No special oil is necessary, it is stated; just a standard quality lubricating oil is used.

Lubrication is absolutely automatic, it is claimed always in proportion and starting and stopping with the machine.

New Features of No. 9 Steam Trap

THREE IMPORTANT FEATURES have recently been added to the No. 9 steam trap shown here.



NO. 9 TRAP, SHOWING THE IMPROVED CONSTRUCTION

Four more corrugations have been added to the bellows' helical tubing to distribute the element's movements over a total of 14 corrugations and thus to minimize its wear and add to its life.

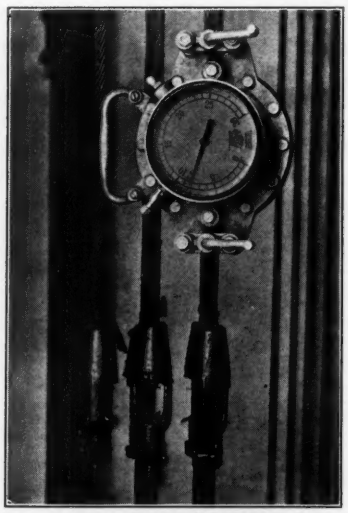
The thermo sensitive element is now surrounded by a heavy brass shield to protect it against possible damage by water hammer and to keep it clear of dirt, rust and other sediment in the steam lines.

The new valve heads are designed to move freely and, under the pressure of the bellows, always to center perfectly in the seat. This feature is intended to insure a tightly closing valve and to eliminate the possibility of off center valve heads, which would allow live steam to escape. The improved trap is a product of Sarco Co., Inc., 183 Madison Ave., New York.

Cable Tension Indicator

FOR MEASURING the tension in wire cable and rope, the tension indicator shown here has been developed by Martin-Decker Corp., Long Beach, Cal.

It is clamped to the cable and indicates on a dial or



EQUALIZING ELEVATOR CABLE TENSION WITH THE INDICATOR

it may be fitted with a recording gage in addition. It weighs 11½ lb. It is fitted with a zero corrector and is designed to be unaffected by ordinary temperature changes of 30 or 40 deg., as it is filled under vacuum with an anti-freeze fluid. The heavy-duty type is designed for use on any line from ½ to 2½ in. and for loads up to 260,000 lb. on a single line; another type measures up to 500,000 lb. It is adapted to measuring tension in crane and derrick cables, elevator cables messengers, guy lines and so on, also to equalizing loads as shown in the picture.

Expander for Small Tubes

TOM THUMB MODEL is the name given by the Key Boiler Equipment Co., East St. Louis, Ill., to a tool

THIS TUBE EXPANDER IS FOR ⅝ TO 1⅛-IN. TUBES

it has developed for expanding small diameter tubes, as in heat exchangers, condensers, boilers, stills, feedwater heaters and so on.

This tube expander is designed to be self-feeding

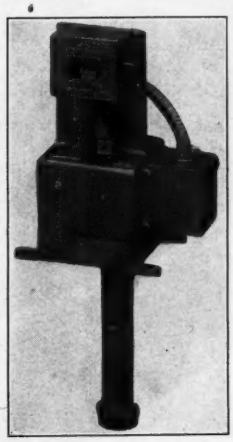
and to be adapted for hand or power use. It is made up for tubes with outside diameters from 5/8 to 1 1/8 in. It is also made up for four different tube sheet thicknesses varying from 1/2 to 1 1/2 in.

Electrical Device for Proportioning Chemicals

MECHANISM to control the amount of chemicals fed in correct proportion to the water to be treated, in lime and soda water softening, is shown on the accompanying illustration. This is an electrical device designed to take the place of the usual proportioning apparatus. Since no water or chemicals come in direct contact with it, its accuracy is not effected by use, it is stated. It is small, compact and operates in oil, to insure long life.

In operation this device receives electrical impulses from two contacts fitted to the head of a standard water meter. Variations in flow directly affect the number of impulses which are transferred by this device to the mechanical movement, thus controlling directly skimming pipes and other means of removing chemicals from the mix tank, which is then delivered by the usual means to the softener precipitation tank.

An important feature is that the proportioning device is designed to be readily and quickly adjusted to accelerate or diminish the feed of chemical in proportion. That is, the device not only operates in direct



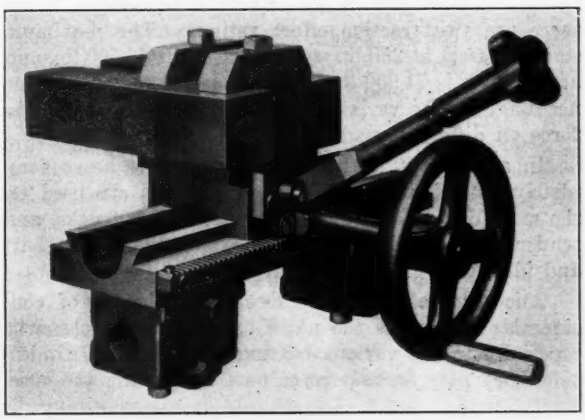
ELECTRICAL CHEMICAL PROPORTIONER

relation to the volume of water to be treated but it can in turn be adjusted to feed greater or less amounts when variations occur according to the desire of the operator. This feature, it is said, eliminates the necessity of waiting until the chemical mix tank is empty before changing the strength of the chemical and makes it possible to change the strength of the chemical feed immediately. It is produced by the Paige and Jones Chemical Co., Hammond, Ind.

FLASH POINT of an oil is merely an indication of the vaporizing characteristics or volatile properties of the oil. It is defined as the temperature at which the oil gives off sufficient vapor to ignite in the presence of an open flame.

Ideal Model Precision Commutator Grinder

PRECISION commutator grinder, known as the Ideal model, shown herewith, has recently been developed for commutators whose eccentricities are too great to be removed with hand-type resurfacers. Use of this grinder, attached to a portable and adjustable bracket, mounted or clamped to the armature bearing supports, is intended to eliminate the necessity of dismantling the motor to turn down the commutator on a lathe. The saving in time and labor is obvious, even where a sufficiently large lathe is available. Accuracy to 0.001 in. is claimed for this device, because commutators are trued in their own bearings at normal speed and under the machine's own



PRECISION COMMUTATOR GRINDER HAS RACK GEAR FOR FASTER CROSS FEED

power. Any eccentricities or slaps characteristic to the machine, caused by centrifugal force, are then present and the truing is done accordingly.

The Ideal Model precision grinder is designed to be used within a space the same length as the base. There are no protruding parts on the side; the cross feed wheel is in the back, which makes it possible to use this grinder on all of the newer types of commutators which have outboard fans or other obstructions. A rack gear in place of screw feed is used to give faster crossfeed motion. The manufacturer is the Ideal Commutator Dresser Co., 1033 Park Ave., Sycamore, Ill.

New Locomotive in Service

FOR SOME TIME there has been a decided interest in the possibilities of anti-friction bearings as applied to the axle journals of steam locomotives. Since various factors make it difficult to replace theoretical with practical data by ordinary methods, the engineers of The Timken Roller Bearing Co., Canton, Ohio, decided to build a locomotive, equipped throughout with Timken bearings and capable of operation on both freight and passenger runs. It was to serve as a means of obtaining complete and accurate data on every phase of bearing performance, under every variety of operating conditions. The plan further called for lending the locomotive to different railroads for varying periods, to be used in their regular service. During its stay on each road its performance, and that of the bearings, is to be

carefully observed and recorded. It is estimated that two years would be required to complete the tests.

In pursuance of the plan, the American Locomotive Co. was commissioned to build a locomotive, of the 4-8-4 type, according to specifications furnished by Timken engineers. It was completed, and had its preliminary trials, a short time ago, and was turned over to the Pennsylvania Railroad for its first test late in May. The service for which it is intended, and the fact that is equipped with tapered roller bearings necessitated several novel features in design and construction. Essentially, it has a total length, with tender, of 102 ft., and a total weight of 711,500 lb., the engine weight being 417,500 lb., and that of the tender 294,000 lb. It has a maximum speed of 85 mi. per hour, and operates on two alternative steam pressures, 250 and 235 lb. respectively. The weight on the drivers is adjustable, hence there are two tractive effort ratings. The maximum starting effort at 250 lb. steam pressure is 76,500 lb., and at 235 lb. it is 71,900 lb. An alternative rating is made necessary by the variations in the weight limitations in force on different roads.

In addition it is the first locomotive to be so completely antifrictionized. Timken bearings are used on the main drivers, the engine trucks, trailer trucks, and tender trucks. They are also used on the crank shaft and idler gear of the Franklin booster.

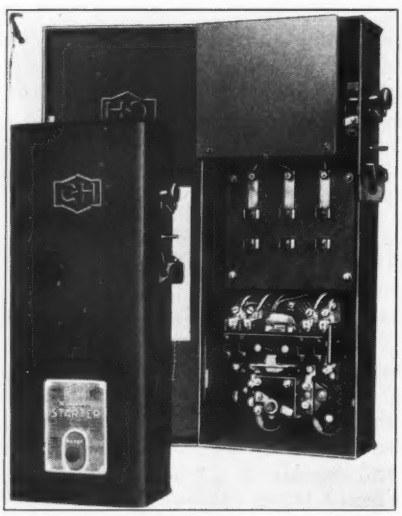
Another feature of the locomotive that is of considerable interest is the novel use of alloy steel parts, especially in the various bearing mountings. In addition, they play an important part in meeting the space, to simplify installation and to present a neater appearance.

A feature is a wiring channel between the starter panel and the back of the enclosing case to allow running the connecting wires behind the panel, where they cannot interfere with the operation of the starter. Ample room is provided to bring all of the connecting wires in at either the top or the bottom of the case according to installation requirements. All parts are mounted on a back plate which is easily removed for pulling and placing of line and motor wiring.

The disconnect switch is manually operated from the outside of the enclosing case. A cover interlock is used to prevent opening the cover when the switch is closed and to prevent closing the switch if the cover is open, unless the interlock is manually released. An electrical interlock is provided to insure that the magnetic contactor of the starter is always open when the disconnect switch is open. The fuse clips are mounted on a slate base, just below the disconnect switch. Fuses are not furnished.

Motor Starter with Fusible Disconnect Switch

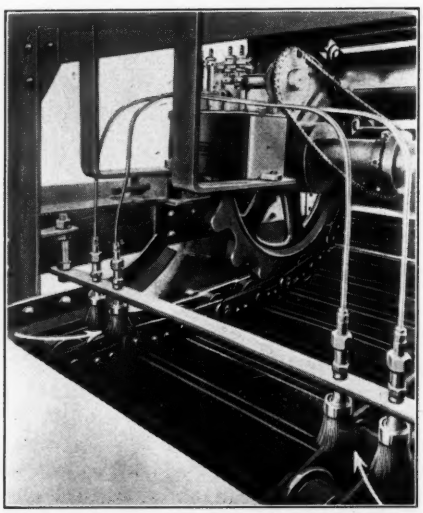
DEVELOPMENT of a new a.c. across-the-line, automatic starter combined with a fusible disconnect switch in a single steel enclosing case, is announced by Cutler-Hammer, Inc., 191 12th St., Milwaukee, Wis. This new starter is designed to be used in place of the separate starter and fusible disconnect switch, to require less



ACROSS-THE LINE A.C. MOTOR STARTER WITH FUSIBLE DISCONNECT SWITCH

Conveyor Lubrication

HERE IS an interesting adaptation of a force feed lubricator to a difficult oiling problem. The photograph shows how a large company lubricates a heavy-duty apron conveyor used for carrying filled and empty



LUBRICATOR SENDS OIL TO BRUSHES THAT LUBRICATE CONVEYOR CHAIN

drums. The lubricator is mounted on the under or slack side of the conveyor. Oil is forced, by the pump, to the brushes shown, through ¼-in. copper tubing. As each link in the chain passes beneath the brushes, it is coated with a film of oil. The Hills-McCanna lubricator used on this installation is a four-feed unit driven by a sprocket and chain from one of the main drive shafts.

APRIL SALES of mechanical stokers, as reported to the Department of Commerce by the 10 leading manufacturers in the industry, totaled 102 with 34,790 hp., as compared with 85 of 27,951 hp. in March and 141 of 48,749 hp. in April, 1929.

L. W. Chubb Appointed Director of Westinghouse Research

L. W. CHUBB, former manager of the Radio Engineering Department of the Westinghouse Electric & Manufacturing Co., has returned to the company as director of the Westinghouse Research Laboratories. Announcement of his return was made by R. S. Feicht, director of engineering. For some months past, Mr. Chubb had been located in Camden, W. Va., as assistant to the vice-president of the Radio Victor Co.

Mr. Chubb is a native of Fort Yates, N. D. He was graduated from the Ohio State University, class of 1905. His alma mater conferred upon him the degrees of

L. W. CHUBB

mechanical engineer and electrical engineer. The year of his graduation, he entered the apprenticeship course of the Westinghouse Company. Upon completion of his training in that special course, he was given a position in the company's engineering department, where he was assigned to the laboratory of standards.

In 1907, he joined the research division and carried on a large number of scientific investigations. His research work in the preparation and properties of magnetic steel are especially noteworthy. On two occasions, he represented America in international electro-technical conventions held in Europe. Mr. Chubb is filling the position left vacant by the promotion of S. M. Kintner to assistant vice-president.

Public Service and Gas Co., Newark, N. J., Receives Charles A. Coffin Award at N.E.L.A. Convention

PUBLIC SERVICE ELECTRIC AND GAS CO., Newark, N. J., has developed a system through interconnection and other engineering improvements benefiting both the company and its customers. As a direct result, the generating stations of the company were able to produce 65,000,000 additional kilowatt-hours of energy in 1929, compared with 1928, at a decrease in cost of $565,000 and the benefit was passed on to the customers in lower electric rates.

This was one of the outstanding achievements which led to the company's receiving the Charles A. Coffin Foundation award at the annual convention of the National Electric Light Association, at San Francisco on June 19. Thomas N. McCarter, president of the company, received the award. The Charles A. Coffin prize, awarded annually to that central station company which has done most for the advancement of the electrical art, was established by the General Electric Co. in honor of the company's founder. With the award goes a check for $1000 to be placed in the treasury of the company's mutual benefit association.

Electrical Engineers Elect Officers

WILLIAM S. LEE, consulting engineer, and president, W. S. Lee Engineering Corp., Charlotte, N. C., was elected president of the American Institute of Electrical Engineers for the year beginning August 1, 1930, as announced at the Annual Meeting of the Institute held at Toronto, Ontario, June 23, during the Annual Summer Convention of the Institute. The other officers elected were: Vice-Presidents I. E. Moultrop, Boston, Mass.; H. P. Charlesworth, New York, N. Y.; T. N. Lacy, Detroit, Mich.; G. C. Shaad, Lawrence, Kans.; H. V. Carpenter, Pullman, Wash. Directors A. B. Cooper, Toronto, Ont.; A. E. Knowlton, New York, N. Y.; R. H. Tapscott, New York, N. Y. National Treasurer George A. Hamilton, Elizabeth, N. J. (reëlected).

These officers, together with the following holdover officers, will constitute the Board of Directors for the next administrative year, beginning August 1: Harold B. Smith (retiring president), Worcester, Mass.; R. F. Schuchardt, Chicago, Ill.; Herbert S. Evans, Boulder, Colo.; W. S. Rodman, Charlottesville, Va.; C. E. Fleager, San Francisco, Calif.; E. C. Stone, Pittsburgh, Pa.; C. E. Sisson, Toronto, Ont.; F. C. Hanker, East Pittsburgh, Pa.; E. B. Meyer, Newark, N. J.; H. P. Liversidge, Philadelphia, Pa.; J. Allen Johnson, Buffalo, N. Y.; A. M. MacCutcheon, Cleveland, Ohio; A. E. Bettis, Kansas City, Mo.; J. E. Kearns, Chicago, Ill.; C. E. Stephens, New York, N. Y.

PRODUCTION OF ELECTRIC POWER by public utility power plants in the United States for April, 1930, reached a total of 7,960,223,000-kw-hr., an increase of 19 per cent over the output for April, 1929. Of the total for April, 1930, 4,687,666,000-kw-hr. were made by fuel and the remainder, 3,272,557,000-kw-hr., by water power.

The change from March to April in the daily production of electricity shown by the records for the last 10 yr. has been a reduction, ranging from 2 to 9 per cent and averaging nearly 6 per cent, according to the Geological Survey. As the daily output for April of this year was about 1 per cent greater than that for March, it may be considered that there was a marked increase in the demand for electricity in April, which was sufficient to more than counteract the usual seasonal decrease. These figures indicate that there was an improvement in general business conditions in April as compared with March. The total production of electricity in April of this year was about 1 per cent larger than that in April of last year.

The output of electricity by the use of water power in April was the same as for April a year ago and was 41 per cent of the total output of the month. This percentage indicates that the output of electricity by the use of water power is probably close to normal, inasmuch as the production of electricity by public-utility power plants in April was about the same as a year ago.

News Notes

MONEL METAL FINISH, designated as No. 8, has been developed by the Huntington Mill of the International Nickel Co. to replace those finishes formerly known as No. 3 and No. 4. It has a silver satin-appearance with more lustre than both of the latter but without the high reflectivity of the full finished No. 5. It was developed to eliminate the need on the part of fabricators for further polishing of their products after manufacturing operations are completed. The No. 8 is claimed to be more attractive in appearance than the two finishes which it replaces. It can also be used instead of No. 5 for some purposes.

GEORGE F. KLEIN, mechanical engineer and until recently director of the Kansas City Coal Service Institute, has become associated with Heat Service Inc., 2525 Pennway, Kansas City, Mo., president and general manager.

NATIONAL POWER MACHINERY CORP., New York Agents of Escher Wyss & Co., Zurich, Switzerland, state that the Tata Iron & Steel Co., Ltd., of Jamshedpur, India, has recently given the Escher Wyss Co. an order for two large turbo-blowers for their new blast furnaces. Each of these steam-turbine-driven blowers is to be capable of delivering 130,000 cu. ft. of free air per minute against a pressure of 27 lb. per sq. in. gage. The air from the blowers passes through suitable air heaters before entering the blast furnace. The steam turbines driving these blowers have a capacity of 13,700 hp. each.

The blast furnaces require the turbo-blowers to operate under wide variations of load and revolutions per minute and the blowers must remain under the control of an air volume regulator, designed automatically and exactly to control the volume of air delivered.

These two blast furnace blowers will be the largest units that have ever been built for this purpose, it is stated. Each unit, it is claimed, will blow a single blast furnace having a capacity of about 1600 t. of pig iron per day. An idea of the size can be obtained from the fact that the total consumption of pig iron in Switzerland is about 80,000 t. a year, so that one of these blast furnaces could produce this entire supply in fifty days.

ADDITIONS to the plant itself and its equipment, to increase the production of Tube-Turns, Inc., Louisville, Ky., were announced by Walter H. Girdler, president of the Girdler Corp., which operates the Tube-Turns company. Construction of the addition to the factory itself will be completed by July 1 and the new equipment will be ready for operation by August 1, according to Mr. Girdler.

C. A. SMITH, chief engineer of the Bigelow Liptak Corp., Detroit, Mich., is leaving that organization to become chief engineer of the Mexico Refractories Co., Mexico,Mo. H. S. Ford, formerly of the Beaumont Mfg. Co., Philadelphia, Pa., is to join Bigelow Liptak Corp.

WAGNER ELECTRIC CORP. of St. Paul, Mo., announces the appointment of H. W. Petty as branch sales manager for Pittsburgh territory, with office at 5031 Liberty Ave., Pittsburgh, Pa.

NORTH AMERICAN REFRACTORIES Co., Cleveland, Ohio, announces the purchase of the assets, good will and business of the United States Refractories Corp. of Mt. Union, Pa., and the Savage Mountain Fire Brick Co. of Frostburg, Md. This places the North American Refractories Co. in a position to supply all grades of refractories, produced by every known process, from raw materials in Pennsylvania, Maryland, Ohio, Kentucky, and Missouri. The entire organization of these concerns, headed by President Thomas N. Kurtz, becomes part of the official North American family.

STEWART N. CLARKSON has resigned as assistant director of the National Electrical Manufacturers Association, and established offices at 522 Fifth Avenue, New York, for the purpose of rendering an intimate trade association service to a few groups of competitive manufacturers.

THE BOILER ENGINEERING Co., Newark, N. J., announces the appointment of G. L. Simonds, Winter Haven, Fla., to represent the company in the state of Florida.

THE GAS COMBUSTION Co. and Duquesne Burner Service Co. have joined the Swindell-Dressler Corp. with offices and plant at Pittsburgh, Pa. The address is P. O. Box 1753.

BLAW-KNOX INTERNATIONAL CORP. is the new name for the export organization of the Blaw-Knox Co., formerly known as Milliken Bros.-Blaw-Knox Corp., which in turn succeeded the original Milliken Bros. Mfg. Co. The change of name does not mean any change in personnel and the offices will remain as formerly in the Canadian Pacific Bldg., New York City.

WAGNER ELECTRIC CORP., St. Louis, Mo., announces the addition of Herbert Hoover to its Philadelphia sales office. Mr. Hoover graduated in electrical engineering at the University of Oklahoma. He was previously general distribution engineer for the Potomac Electric Power Co. Before that he was a member of the U. S. army as a member of the Dawes Commission. In 1919 he supervised operation of overhead transmission systems for the Empire District Electric Co.

THE TOTAL PRODUCTION of soft coal during the week ended June 7, including lignite and coal coked at the mines, is estimated at 8,154,000 net tons. This is a gain of 564,000 tons over the holiday week preceding, but it is 118,000 tons, or 1.4 per cent, lower than the output in the full-time week ended May 24. Production during the week in 1929 corresponding with that of June 7 amounted to 9,278,000 tons.

THE TOTAL PRODUCTION of soft coal during the present calendar year to June 7 (approximately 135 working days) amounts to 205,073,000 net tons. Figures for corresponding periods in other years are given below:

1929.....226,455,000 net tons	1927.....246,080,000 net tons
1928.....208,771,000 net tons	1926.....237,404,000 net tons

IN SPITE OF the fact that the production of electricity in April was slightly higher than in the corresponding month last year, the consumption of coal by the electric public utilities remained somewhat short of last year's record. Total consumption for the month amounted to 3,233,100 tons as compared with 3,413,940 tons in April, 1929, a decrease of 180,840 tons, or 5.3 per cent. Other than the Lower Missouri Valley and Lake Dock Territory, both of which continue to show a substantial gain over last year, the decrease was shared by all regions in the country.

TOTAL PRODUCTION of Pennsylvania anthracite during the week ended June 7 is estimated at 1,199,000 net tons. This is a decrease of 49,000 tons, or 3.9 per cent, from the output in the preceding week when, because of the Memorial Day holiday, there were but five working days. Production during the week in 1929 corresponding with that of June 7 amounted to 1,060,000 tons.

MAY SALES of mechanical stokers as reported to the Department of Commerce by eleven leading manufacturers in the industry, total 96 with 31,956-hp. as compared with 108 of 35,903-hp. in April and 174 of 60,772-hp. in May, 1929. Of the total for May, 1930, 41 stokers were installed under 5703-hp. of fire-tube boilers and 55 stokers under 26,253-hp. of water-tube boilers.

Books and Catalogs

LITTLEFORD BROS., Cincinnati, Ohio, has recently issued a catalog on plate and sheet steel fabrication which gives an outline of the service as it is understood and executed by the company. The book is profusely illustrated with color plates and carries the reader through the history of the product from the receipt of a contract to the time it is in service.

PURE WATER from the Sea at Low Cost by use of Lea distillation process is discussed in a recent bulletin issued by Henry I. Lea, Gas Engineer, Mesa and Latimer Roads, Santa Monica, Calif.

PATTERSON FEED WATER HEATERS, their internal construction, connections and use of various types are discussed in a 12-page bulletin by Patterson-Kelley Co., 101 Park Ave., New York.

SARCO COMBINATION FLOAT and Thermostatic Steam Trap, designed for pressure up to 125-lb. per sq. in. is illustrated and described in a recent circular by the Sarco Co., Inc., 183 Madison Ave., New York.

THE LIPTAK Double Suspension Arches, designed for increased efficiency and reduced maintenance, are described in Catalog 17 just issued by the Bigelow-Liptak Corp., Detroit, Mich. Details of the arch blocks and their method of supporting them are shown by photographs and two color drawings and various methods of using the arch with all types of combustion equipment are shown in detail by drawings.

BAROMETRIC MULTI-JET Condensers designed for use with evaporators, vacuum pans and similar process equipment, are described and illustrated in color in Bulletin 5-AA just published by Schutte & Koerting Co., Philadelphia, Pa., superseding the previous edition of this bulletin. Performance data from actual installations of these condensers are given and interesting drawings and photographs show the different ways in which they can be applied.

IN A RECENT 30-page illustrated bulletin sent out by James T. Castle, 424 First Ave., Pittsburgh, Pa., the Peerless Pump Co., Los Angeles, Cal., describes Peerless Deep Well Turbine Pumps for 6 to 18 in. diam. wells or larger, also from 30 to 7000 g.p.m. for lifting water from any practical depth.

RELIANCE FULLY-ENCLOSED Fan-Cooled Induction Motors, Type AA Form F with ball bearings for two and three-phase alternating-current circuits are described in bulletin 107 by Reliance Electric & Engineering Co., Ivanhoe Road, Cleveland, Ohio.

DAYTON COG-BELT DRIVES are described in Catalog No. 102 by the Dayton Rubber Manufacturing Co., Dayton, Ohio. General description is given of the drives, installation views, data on

standard stock drives of all sizes with tables of dimensions and calculation data for various types of drives. Prices and special features are discussed in the last part of the book.

FOREIGN DEVELOPMENTS are discussed in N.E.L.A. Publication No. 042 just issued as a report of the Prime Movers Committee, Engineering National Section, National Electric Light Association, 420 Lexington Ave., New York City. Recent installations and future plans continue to show a trend toward higher pressures and temperatures, the latter in particular, and considerable work has been done in connection with suitable materials for the changed conditions. Great activity was shown by the manufacturers of equipment and the design tendency has been toward an increase in size of turbines and greater capacity in boilers. The problem of fly ash, dust and waste gases remains to be solved and it is perhaps significant that several of the new stations are designed for stoker firing. The advantages of interconnected operation are appreciated and a number of system extensions are under way.

POWER STATION BETTERMENT is discussed in N.E.L.A. Publication No. 004 just issued, a report of the Prime Movers Committee, Engineering National Section, National Electric Light Association, 420 Lexington Ave., New York City. This report indicates station betterments possible through modernization by addition of new equipment or remodeling of old. Four examples of station betterment by minor capital expenditures are given, intended to show what can be done toward increasing capacity or improving economy, with existing apparatus. The examples selected represent: 1. A substantial rebuilding. 2. A modernization of the boiler house. 3. A modification of heat balance. 4. An increase in boiler capacity by the use of larger stokers and water walls; minor improvements of stokers; baffle changes in Stirling boilers.

HIGHER STEAM PRESSURES and Temperatures are discussed in N.E.L.A. Publication No. 053 just issued, a report of the Prime Movers Committee, Engineering National Section, National Electric Light Association, 420 Lexington Ave., New York City. The report discusses thermal economies resulting from the use of steam pressures between 500 and 1500 lb. and of steam temperatures about 750 F.; construction costs and operating results in their relation to steam conditions; and properties of various alloys at high temperatures. An excellent view is given of present practice and research, particularly in this country, with respect to higher steam pressures and temperatures.

TREATMENT OF FEEDWATER is discussed in N.E.L.A. Publication No. 051 just issued, a report of the Prime Movers Committee, Engineering National Section, National Electric Light Association, 420 Lexington Ave., New York City. Recent developments are reported concerning: 1. Study made to determine proper ratios for prevention of boiler metal embrittlement. 2. Effect of acid, neutral or alkaline waters and metal stresses on boiler metal cracking. 3. Method of removing oxygen from feedwater for 1300 lb. per sq. in. boilers. 4. Experience in the use of continuous blow down with heat exchangers. 5. Methods of boiler feedwater treatment that have given good results. 6. Results of carry-over tests and methods used.

DRAFT TUBE TESTS are discussed in N.E.L.A. Publication No. 047 just issued, a report of the Hydraulic Power Committee, Engineering National Section, National Electric Light Association, 420 Lexington Ave., New York City. The data on draft tube tests presented in this report demonstrate the importance of tests of model turbine settings and their incalculable value in working out draft tube designs to meet specific space requirements. The test material is presented in a series of plates from which deductions of comparative performances can be made. The plates show the test data and tube proportions, supplemented by a descriptive summary including more general information bearing on the tests. It is classified under three main heads as follows. Class A—Tests of small model draft tubes without runners. Class B—Tests of model tubes with model runners. Class C—Tests of identical turbines with different types of draft tube. A bibliography on the subject of draft tubes is appended.

RELATIVE DECLINE in the trade of the United States with Europe and Asia and a steady increase in the proportion of its trade with Latin America are forecast in a study entitled "Trends in the Foreign Trade of the United States" just completed by the National Industrial Conference Board, 247 Park Ave., New York.

Since the beginning of the century, the foreign trade of this country has more than doubled in volume, the study reveals. A large part of this increase occurred during the war and in the post-war period, the expansion since just before the war being estimated at between 50 and 60 per cent. The foregoing figures relate to actual volume of goods exchanged. In dollar values, the foreign trade of this country during the last three decades has more than quadrupled, rising from two and one-quarter billions in 1900 to approximately 9.6 billions in 1929. The dollar values of imports increased from an average of 1.7 billions for the years 1910-1914 to 4.4 billions in 1929, while exports rose during the same period from 2.2 billions to 5.2 billions.

Of perhaps even more significance than the growth in the foreign trade of this country, the Conference Board states, is the change in its composition, particularly that of exports. Whereas at the beginning of the century foods and materials constituted from 75 to 80 per cent of the exports of this country, and just before the war about 70 per cent, the proportion of finished manufacturers steadily increased until, in 1929, it comprised nearly one-half of this country's exports.

As regards imports, the proportion of finished manufactures and foods to total imports has gradually declined in favor of materials—finished goods declining since 1900 from 25 to 23 per cent and foods from 27 to 22 per cent, while the share of materials, both crude and advanced, increased during the same period from 47 to 55 per cent. The decline in the proportion of finished manufactures in total imports is not so significant as the change in the character of the finished articles. In former years, the United States imported many manufactured articles which it now makes itself, and its imports to an increasing extent are composed of specialty articles which this country can not produce as advantageously as other countries.

The Conference Board points out that the change in composition of American exports has placed the responsibility for an expanding exports trade directly upon the producers in this country. When this country's exports consisted largely of foods and materials, it could depend on a more or less stable market for its products, but with the transition in its exports from foods and other staples to finished manufactures, the initiative in creating outlets and in increasing the volume of exports has devolved upon the manufacturer of such products. This responsibility which has fallen upon those manufacturing for export has resulted in a growing demand for information regarding prospective markets.

The Conference Board's analysis has disclosed a number of interesting facts respecting the trends of foreign trade of this country. For example, although the United States has regularly had an excess of exports, this export balance steadily declined from 1900 until the last couple of years, when it again shot sharply upward, thus reversing the general trend. The export balance of this country, it may be noted, has not been general for all classes of commodities. Indeed, since the close of the war only finished manufactures have maintained a consistent export balance. There has been an excess of imports over exports during the post-war period in both the crude and advanced materials groups, and the export balance in foods has gradually declined until in 1928-1929, imports considerably exceeded exports.

Similarly, the export balance shown in the total foreign trade of this country is not found consistently in trade with each geographic region; the rule has held for Europe, North America, Oceania and, except during the years 1921-1925, for Africa, but not for the other divisions of the world. Imports from Asia and South America have greatly exceeded exports to those regions, but in South American trade there has since the war been a steady and substantial rise in the relative proportion of exports to imports.

MODERN METHODS OF ASH HANDLING is the title of a new 24-page catalog illustrating several methods of handling ash by pipe line, as well as other types of ash conveying by the Brady Conveyors Corp., 20 W. Jackson Blvd.

IMPORTANT PROGRESS in standardization work affecting mechanical, electrical, railways, mining and other major American industries is reported in the American Standards Year Book for 1930, just published by the American Standards Association, 29 W. 39th St., New York.

Among the high spots of the standardization movement during the past twelve months, the Year Book notes:

The underwriting by industry of $500,000 for the promotion of national standardization during the next three years.

The affiliation of the American Standards Association with the national standardizing bodies of twenty other nations, through the International Standards Association. This body, which has its headquarters at Zurich, Switzerland, will promote international coöperation in standardization work.

Increased recognition of the value of national industrial standards in the field of foreign trade.

The completion of an agreement between the American Standards Association and the United States Bureau of Standards providing for a maximum degree of coöperation between the government and private bodies in the promotion of industrial standardization.

Power Plant Construction News

Ark., Paragould—The City Council is said to be planning a bond issue of $125,000, for a proposed municipal electric light and power plant, for which plans will be drawn at an early date.

Calif., Newark—The California Chemical Co., 111 Sutter Street, San Francisco, plans installation of electric power equipment in new line plant at its work at Newark, project to cost about $1,000,000.

Calif., Pittsburgh—The Shell Chemical Co., a subsidiary of the Shell Oil Co., 200 Bush Street, San Francisco, plans installation of electric power equipment in proposed new nitrogen fixation plant at Pittsburgh, entire project reported to cost over $4,000,000.

Colo., Stratton—The Inland Utilities Co., Havana, Kans., has plans for a steam-operated electric power plant at Stratton, with installation of oil-operated engine and auxiliary equipment, reported to cost close to $40,000.

Fla., Fort Pierce—The Fort Pierce Growers Association, Fort Pierce, contemplates a cold storage and precooling plant in connection with new local packing house, entire project to cost more than $250,000.

Ga., Cordele—The Crisp County Power Commission, Cordele, has approved plans for a new power plant and will proceed with superstructure at once, project reported to cost over $100,000, with equipment.

Idaho, Silver City—The Trade Dollar Consolidated Mining Co., has plans under way for a hydroelectric power plant at Swan Falls, on the Snake River, for service at mill, project reported to cost over $200,000. A. J. Wiley is chief engineer.

Ill., Chicago—The Wisconsin Steel Works, 2701 East 106th Street, plans installation of electric power equipment in proposed new mill unit for which plans have been filed. Estimated cost about $175,000.

Ill., Galesburg—The Standard Oil Co., Galesburg, is said to be planning the installation of pumping equipment and auxiliary apparatus in connection with proposed oil storage and distributing plant, entire project to cost about $100,000.

Ill., Villa Park—The Board of Local Improvements, Village Hall, is having plans completed for a one-story pumping plant for municipal sewage system to cost about $25,000, with equipment. Edwin Hancock, 1509 West Jackson Boulevard, Chicago, is engineer.

Iowa, Cedar Rapids—The Penick & Ford Co. plans installation of electric power equipment in new addition to local starch plant, entire project to cost over $120,000.

Iowa, Creston—The City Council is having plans completed for a filter plant for the municipal waterworks to cost about $35,000. The Currie Engineering Co., Hamilton County State Bank Building, Webster City, Iowa, is engineer.

Ky., Louisville—The National Consumers Oil Co., Inc., Terre Haute, Ind., plans installation of electric power equipment, pumping machinery, etc., in proposed oil compounding, storage and distributing plant at Louisville, entire project to cost close to $200.000.

Md., Catonsville—The Board of Baltimore County Commissioners, Court House, Towson, has plans under way for a one-story pumping plant at Catonsville, to cost about $50,000, with equipment. B. E. Crozier, address noted, is County Engineer.

Mich., Dearborn—The Ford Motor Co. will carry out an expansion and improvement program at local power plant to cost close to $1,000,000, in connection with other plant extensions on which work has been started, to cost more than $2,000,000.

Mich., Detroit—Parke, Davis & Co., McDougall Avenue, has plans under way for a one-story power plant addition at drug and chemical factory, reported to cost over $50,000, with equipment. Smith, Hinchman & Grylls, Marquette Building, are engineers.

Mich., Saginaw—Wilcox-Rich Corporation, Rust Street, plans installation of electric power equipment in proposed new addition to automobile equipment plant, entire project to cost over $125,000. Cowles & Mutcheller, Adams Building, are architects.

Mo., St. Louis—The American Car & Foundry Co., De Kalb Street, plans installation of electric power equipment in proposed new addition to plant to cost over $275,000.

Mo., St. Louis—The Board of Education has completed plans for a one-story power plant, 70x150 ft., for central service for school buildings, reported to cost over $80,000, with equipment. George W. Sanger is acting commissioner of school buildings.

Mo., St. Louis—The Federal-Brilliant Co., 3531 Washington Avenue, plans installation of electric power equipment in new four-story glass tube plant, entire project reported to cost over $100,000. Aegerter & Bailey, Railway Exchange Building, are architects.

N. J., Keyport—The City Council is said to be planning installation of pumping machinery and auxiliary equipment in connection with extensions and improvements in the municipal waterworks, for which a bond issue of $175,000 has been authorized.

N. J., Sewaren—The Shell Eastern Petroleum Products, Inc., 122 East Forty-second Street, New York, has plans under way for a boiler plant at local oil works, reported to cost close to $50,000, with equipment. H. S. Bell, 233 Broadway, New York, is engineer.

N. C., Monroe—The Common Council contemplates a municipal electric light and power plant and waterworks, and is considering estimates of cost. Sherritt & Co., 208 South La Salle Street, Chicago, Ill., are engineers.

Okla., Chelsea—The Common Council is considering extensions and improvements in the municipal electric light and power plant, including the installation of Diesel engines and accessory equipment.

Pa., Etna—Spang, Chalfant & Co., Inc., Clark Building, Pittsburgh, recently merged with the National Supply Co., Frick Building, Pittsburgh, plans installation of electric power equipment in connection with an expansion and improvement program at steel pipe mills at Etna, entire project reported to cost over $400,000.

Pa., Pittsburgh—The Union Gulf Corporation, a subsidiary of the Gulf Oil Corporation, Frick Annex, Pittsburgh, plans installation of electric power equipment in proposed new oil refining plant on Neville Island, entire project to cost more than $4,000,000.

R. I., Cranston—The Universal Winding Co., plans installation of electric power equipment in proposed three-story addition to textile mill, entire project reported to cost close to $100,000.

Texas, Brownsville—The City Council is asking bids until July 23, for a purification plant for municipal waterworks with capacity of 40,000,000 gals. per day, to include installation of five filter units. Entire project is estimated to cost $125,000. Morey & Morey, Pretorian Building, Dallas, are engineers.

Texas, Corpus Christi—The Central Power & Light Co., San Antonio, is reported planning a new power plant on the Nueces River, near Corpus Christi, with initial capacity of 20,000 kw. Extensions will be made in transmission lines.

Va., Orange—The Common Council is said to be planning the installation of pumping machinery in connection with extensions and improvements in municipal water plant and sewage system, for which a bond issue of $150,000, has been approved.

Va., Waynesboro—The Waynesboro Cold Storage Corporation, 140 Cedar Street, New York, Edward H. Tatum, president, recently organized, has preliminary plans under way for a cold storage plant at Waynesboro, reported to cost more than $50,000, with equipment.

Wash., Walla Walla—The Northern Flour Mills plan installation of electric power equipment in connection with proposed rebuilding of portion of plant destroyed by fire, June 18, with total loss reported over $200,000.

W. Va., Boncar—The Electro Metallurgical Development Co. of America, Inc., operated by the Union Carbide & Carbon Co., 30 East Forty-second Street, New York, is said to have engaged Ford, Bacon & Davis, Inc., 39 Broadway, New York, engineer and contractor, to prepare plans and supervise construction of proposed new steam-operated electric power plant to cost over $100,000, with equipment.